PRODUCTION ORGANIZATION

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Production Organization

By

E. H. FISH, B.S.

CONSULTANT ON EMPLOYMENT AND SOCIAL SERVICE

THE PLANT AND ITS LOCATION
ORGANIZATION OF PRODUCTION DEPARTMENT
HANDLING MATERIALS
ROUTING THE WORK

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INSTITUTE OF BUSINESS SCIENCE
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PRODUCTION ORGANIZATION

(PART 1)

INTRODUCTION

1. The Object of Doing Business.—Nearly all business is done for the purpose of profit, either present or future. At times, men do business because of the honor and prestige or because it is a duty; but even these things are individual profits for which the particular individual is willing to forego a financial profit. Whether profit should be the principal motive or not, is an interesting question, and perhaps the time will come when other and entirely different motives will actuate manufacturers; but up to the present there appears to be no other incentive that is so effective in making people work as is private gain.

2. Profit.—Manufacturing profit is made by selling goods for a greater price than the cost of materials, cost of manufacture, and cost of distribution. So many things enter into all these costs that the only way to tell where the greatest profits are made or where the greatest losses are incurred is by a carefully kept cost system. It may be that in a business returning a comfortable profit the manufacturing processes are more expensive than those of some other concern making a similar product, which may be losing money through a poor sales organization.

Again, it is entirely possible for two businesses to be conducted by the same concern, and even under the same roof, where the profit arises from entirely different parts of the

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organization. For example, one department may be building machinery that is sold through an agent who contracts for the whole product. Whatever money it makes then must be made in its production, or manufacturing, department. On the other hand, the next department may have the protection of patents, or in some way have a monopoly for the time being, and it may be possible for it to use the most extravagant production methods and yet make a better profit than is possible to the first-mentioned department.

No matter what department may be the most efficient, any improvement in the production department adds to the profit.

3. Factors in Production.—The factors upon which production depends are: (*a*) The plant, including equipment; (*b*) the personnel; (*c*) materials; (*d*) processes of manufacture; (*e*) distribution of product.

Under the heading of *the plant* are to be considered the reasons for locating it in some given part of the world; then its location within that district; the actual site chosen; the type of buildings best adapted to the work to be done; the machinery necessary, including the power plant, handling devices, whether traveling cranes or conveyers or simple chutes; and all the things necessary up to the time that the employes report for work.

Under *personnel* are included all the problems of providing a flow of labor toward the plant without undue disturbance of the labor market for other employers, the training of employes and the handling of them so that the outward flow is only sufficient to prevent stagnation in the force. In connection with personnel, also, must be considered the methods of payment for labor and their general relations to the community, as well as the subjects of housing, transportation, feeding, health, exercise, recreation, etc.

The subject of *materials* relates to the purchase or control of raw materials, fuel supplies, etc., as well as the problem of getting them to the plant and ready for manufacturing processes.

Under *processes of manufacture* are included the varied methods of doing the required work on the materials and the assembly of the finished product, if it is such a product. In this connection must be considered the necessary special tools, jigs, and fixtures for expediting the work, that may not have been included under plant.

The subject, *distribution of product*, deals with the distributing or shipping of the product to customers or agents. This work is on the border line between production and sales and may be handled by either the work manager or the sales manager.

Since production requires attention to all these things, some form of organization is necessary to carry on the business; this organization may be a one-man affair, or line and staff, or it may take in everybody in the plant under some form of employe representation.

THE PLANT

LOCATION

4. Lessons From Old Plants.—Many prosperous plants are seemingly located without reference to any business principles. It will usually be found that such plants have begun in a very small way. Often two men, sometimes only one, have thrown up their jobs and begun together in a little shop handy to their homes. The business has developed slowly, but they have put into it every bit of profit above the barest living expenses for themselves. They have had to have larger and larger quarters, but have always been cramped for money. Consequently, they have built on additions of the cheapest type they could, which resulted in the rambling shop that is so hard to organize effectively. When prosperity reached them and they could build wholly new shops, they have found that the old buildings were worthless for any except their own purposes, and they likely have developed a fondness for the old place that brings sentiment into the question as a large factor. Study of these plants shows things that should be avoided in a new plant, but is not especially helpful so far as planning new buildings for another firm is concerned; for the location was determined by the necessities of the founders, who may have departed far from their original dreams, and during the time they have been building up their business world conditions may have undergone great change.

5. Planning a New Plant.—The man who is fortunate enough to have the opportunity to plan a new shop without the limitations that surrounded the founders of the business is fortunate. If he has the problem of planning a shop to house an entirely new industry which has no traditions, he has an interesting engineering problem, but one which from its very untriedness is full of risks to his reputation and to the stockholders' pocketbooks.

6. Position on the Line From Material to Customer.—The first consideration should be to put the plant somewhere in what may be called the straight line connecting the source of materials and the customer. The expression, *straight line*, as here used, does not necessarily refer to a physical straight line, but it means the most direct and feasible route, taking into account the fact that water freights are normally lower than rail, and that established routes of trade are more certain than those which may be more direct in point of miles.

The time element is often of more consequence than actual miles, though in the case of most manufactured goods the matter of perishability is not a factor. In the canning industry, however, it is, and the vegetables, fish, meat, or whatever is to be canned, are put in the tins at a point as near as possible to where they are raised or caught. The tins themselves need not necessarily be made at that point; in fact, they hardly can be, for one can factory has the capacity to supply many widely distributed canneries. The cans should therefore be made on the line between the source of sheet tin and the best distributing point for the various canneries.

If the raw material is heavy or bulky, there is need that the plant be near the source of supply, especially if distribution is wide and the finished product is more compact or lighter than the material. Such is the case, for example, with a certain type of aeronautical engine in which the block of cylinders is machined from a casting that weighs ten times as much as the finished product. A similar condition exists with an ore like bauxite, from which aluminum is made, which must be reduced to metal where electric power is cheap. The ore as mined carries large quantities of water, which must be calcined out; therefore, since it costs just as much for freight on a ton of water as on a ton of bauxite, it is natural that this first step of the manufacturing process should be carried on at the mines. The same is true of many other products; thus copper smelters are at the mines. However, with large capital and water transportation, and the very best means for handling, it is possible to transport iron ore profitably to the steel mills nearer the user.

Often, because of certain conditions, it may not be advisable to locate the plant on the direct line between the materials and the customer, but the matter should always be taken into consideration when making a first location.

7. Location as Regards Labor Supply.—The question of a supply of labor should be taken into account in deciding on the location. A plant that is to employ only unskilled or semiskilled labor can afford to pass by this problem, provided the business is large enough to justify building a town of its own. The few skilled men and the executives that are always necessary will go to such a town only reluctantly and under the persuasion of high salaries; but the number of these as compared with the great number of laborers may be so small as to be of comparatively little importance. If, on the other hand, the work is such that many skilled men must be employed, it is better to go far enough from the straight line between material and customer to get a ready flow of the desired type of workers. If women are to be employed, it is necessary that the plant be fairly near to large centers of population, though there is an exception in the case of mills that employ entire families in which every one over the State-law age works in the mill. Such families will go anywhere that money is offered. There is, however, a gradually increasing tendency for even the lower grades of labor to inquire into the living conditions, and particularly the schools, of the new community. Therefore, if a town or village is planned, it is necessary to make arrangements for schools from the very beginning.

8. **Assembly of Varied Materials.**—Many manufactured products are made of more than one material. The automobile is an example. Hardly any automobile factory makes its own cranks, or cam-shafts. Each shop may grind them, but the forgings are the raw material in such case. These forgings may not be made on the straight line between their raw material and the automobile factories; in fact, a great many of them are not, and largely for reasons that seem almost sentimental. Also, automobiles must have tires, and the tires are made in still other factories, which come nearer to being on the line between their raw material and their market than do the crank-shafts. Automobiles also must have aluminum castings, which are made from an aluminum alloy. The original raw material of aluminum is a hard clay known as bauxite, which comes from France, Arkansas, or South America. The reduction of the ore necessitates the intense heat of the electric arc, which is most cheaply obtained by water-power. Therefore, unless a manufacturer owns his own water-power he is attracted to the immediate vicinity of Niagara Falls, and there he is handicapped by heavy freight rates from his nearest supply of raw materials.

For the foregoing and many similar reasons the automobile manufacturer cannot get very near to the straight line between his raw material and his customer. This, however, is of comparatively little importance, for his greatest problem is to secure a large supply of help capable of building his car. Such help is located in the large industrial centers and it is difficult to induce it to move; so, regardless of whether these large cities are in the ideal position or not, the automobile manufacturer is almost compelled to accept the location that has been selected by others, and he finally locates his shop in Detroit, Cleveland, or some other large city where many mechanics are employed. He does this because he knows that mechanics congregate where work is known to be plentiful, and also that they readily move from shop to shop. This latter fact is an advantage to him in the beginning, but later is a disadvantage, since it causes a large labor turnover.

9. **City Versus Country Locations.**—Many manufacturing plants of large size are in the business centers of large cities, where they can grow only by building higher in the air. They began probably with much more room than any one dreamed they would need, but when they reached their boundaries the plant was much too expensive to move, and yet was worth what it cost only if the concern kept going. However, in many cases there are great advantages in being centrally located, and these advantages, especially ease of hiring help, may overbalance the high cost of plant and difficult access to materials. Very few of these centrally located plants have adequate railroad facilities for heavy work or for handling either raw materials or product in carload lots. If, however, the work is light, such as the manufacture of paper goods, boxes, valentines, etc., it may be profitable to have the shop near to its employes and pay more for handling the supplies and shipping the product; in general this is true wherever women are employed, except, possibly, in the mills where whole families are taken on at a time. A very considerable number of young women work for spending money rather than for a living. They live at home, have everything that they need supplied, and can pick and choose their jobs. They will not go out into the country from the city; because, if they do, they find the quiet and absence of life painful.

Shops having seasonal work that can be done in the winter can profitably locate in the country where they can draw the farmers who would otherwise loaf all winter or else go to town for jobs. Men who work in the outlying districts during the warm weather are not likely to be any more happy in the city in the winter than are the city people who go out into the country to work. The country people in the city miss the home cooking and the physical comforts which they get on the farm. If they are reconciled to city life, they want to stay there the year round. In recent years the rush to the cities has rendered still more difficult the problem of filling the shops in the country. Many persons deplore this tendency of people to congregate in the large centers, but there are good reasons why it is necessary, the principal one being the fact that there is not room for so many on the farms. Much of the agitation about lack of help to plant and get in crops is unjustified, as the great increase in farm machinery is making it unnecessary to have so many people on the farms, so they are really being crowded into the city by lack of employment outside. A man with a tractor is nearly ten times as efficient as a man with a pair of horses, when the plowing is going on. All this has made it necessary that the man who goes out on a farm shall have capital enough to buy the needful equipment before he begins, if he is to make the farm pay. Therefore, the farm, as a business or as a place of employment, is much more like a shop than ever before.

10. All the signs point toward the necessity of placing shops on the outskirts of large cities, except in cases where other considerations than obtaining help have to control. This is because desirable help simply will not go far from the excitement and interest of city life. They are willing to live outside up to about an hour's travel from work. That is, with the eight-hour day they are willing to spend two hours in traveling to and from work. The shop can be located about a half-hour's ride from the center of the city and the other half hour be allowed for distribution of help to their homes; or the shop can be located an hour's ride out and be surrounded by the homes of the employes. However, in this latter case, the fare for the hour's ride must be very low, indeed.

The questions regarding the actual housing and transportation of help are taken up further on; so that it need only be said here that in some cases approximately as much capital is required to provide housing as to conduct the business. Expenditure for housing can be avoided if the shops are near enough to large centers of population so that easy, quick, and inexpensive transportation can be provided. It should be borne in mind, however, that when all or nearly all of the employes live within a few minutes' walk of the shop, a smaller rate of wages satisfies their needs and desires than if the larger number have to travel by train or trolley and bring or pay for a lunch in the middle of the day. However, merely providing housing for a selected group, or providing it for the few who are unable to get accommodations elsewhere, is not enough to affect the pay roll at all favorably. Wages, as will be explained further on, are determined by the rate demanded by the highest priced men that the concern must have in order to get the production found profitable. Consequently, unless housing is provided nearby for every one who would like it, there is no financial advantage in providing any. Anything that falls short of this contributes only to the unfavorable side of the balance sheet.

11. Industries That Thrive in the Country.—It has already been explained that certain things must be done at the source of supply, as for example the canning of fruits and vegetables, the calcining of aluminum ore, smelting of copper ore, etc. Certain industries that can be curbed in their growth and which employ women largely, thrive in the country; as, for example, the manufacture of straw and felt hats, underwear, neckties, etc., and some of the minor textiles, such as hosiery. These businesses do well until the point is reached where they need the services of more girls than are available in the immediate vicinity and they have to reach out and induce others to come into the town to fill the shops. Any legitimate means of aiding the healthy growth of the community are helpful, but bringing in individuals with no family ties is conducive to poor relations with labor and is very apt to raise the rate of wages, which must necessarily be paid to all alike.

12. Locations Determined by Power Supply.—Many industries are dependent on low-cost power. The aluminum industry has already been mentioned, but the textile industries are equally needful of steady, dependable power at low cost. The materials for textiles are easily transported, the market is everywhere, labor will follow the factories seemingly anywhere, whole families are often employed, and a large proportion of the workers do not require much education or intelligence.

The cheapest power is that of water when conditions are favorable. To be sure, wherever there is water-power for sale in small quantities, as when distributed by power companies like those at Niagara, there is not much difference between the price charged and that charged for power derived from coal, for in such case the difference goes into the profit of the power company. But, if the pond and dam are owned by the factory, the actual cost is very little more than that due to depreciation and interest on the cost of the equipment and dam.

The desirability of steam power is dependent on the ease with which coal may be obtained. The numerous troubles in the coal fields, and the uncertainty as to whether coal can be assured at the factory at any price, make water-power attractive. Because of the ease with which power may now be transmitted for considerable distances by transforming it into electricity and back again at the distant end of the transmission line, the worth of a water privilege is now greater than ever. If, however, the first cost of a water privilege is too high, it is entirely possible that steam may be the cheaper.

Steam is also made by burning crude oil instead of coal. The increasing tendency toward higher prices of fuel oil and the uncertainty in regard to some of the sources of supply give an element of risk to installations for oil burning. Fortunately, most installations of this kind can be made so that, without radical changes in the boiler setting, they can be changed to burn coal in a few days at the outside.

13. Importance of Transportation Facilities.—If the manufacture of watches is contemplated, consideration of transportation facilities for either materials or product is hardly necessary. A freight car that might bring a hundred dollars worth of iron ore to a blast furnace would take away millions of dollars worth of watches.

If, however, the transportation problem is a large factor in the business, as in the case of blast furnaces, machinery, textiles, shoes, etc., then a location on a branch of a large railroad system or where water freight is available, is important. It is not so much the size of the line that runs past the doors that counts, as it is the facilities for getting goods clear through to the purchaser or of receiving materials direct. There is also an advantage in being near a junction point where there is a choice between a number of roads; not that any competition can be aroused between them as to rates, but because much better service is assured. More than that, in times of embargoes due to labor disturbances, or tie-ups due to storms or any other cause, it is usually possible to get goods in and out by some route.

Water freights are normally much less than rail, and have a distinct advantage where time is not an important element. If the business is largely export, proximity to a port that handles shipping to all parts of the world is a great advantage. The effect of such conditions is seen in and around New York City, where a great many manufacturing concerns have come, attracted by the convenience for shipment to any part of the world, and also by the ease of receiving shipments of materials from every source; for here transportation to and from all parts of the world can always be obtained. It does not follow, however, that all exporting should be done from the port of New York. From the point of view of the country as a whole, it is likely that it would be better if all the good harbors along the Atlantic coast had a share of the trade proportionate to their ability to handle it.

14. Dependent Industries.—Certain shops are limited in their range by the necessity of being near certain other shops. Rolling-mill machinery is usually built near rolling mills, though a notable exception occurs in New England. In other cases there is no apparent reason for proximity. For example, Ford accessories are sold wherever the cars go; there is no need that they be manufactured in Detroit, yet it is natural that they should be. Coopers can often profit by putting their little shop next door to a large one that uses their product. Small shops just starting in almost any line often do very well to take a small shop close to the factory in which the new owners were formerly employes. By so doing they are apt to pick up old customers of the large company, who are disgruntled for the time being over some trivial occurrence, and who would probably go home and cool down and forget all about it if the other shop were not right there to catch them while they are still angry.

15. Proximity to Local Markets.—Certain manufacturers of perishable goods, as in the case of restaurants, hotels, bake shops, and to some extent candy shops, are influenced in their location by the question of proximity to their respective customers. It is not enough for them to locate in a prosperous city; they need to be on the street corner where foot travel is the most dense, and on the ground floor, so that their customers will not have to go up steps to get to them. Of course this can be attained in a candy shop, or a bake shop by having the factory elsewhere and only the store located in this very desirable place. Hotels and restaurants, buying flour, vegetables, meat, etc., are in a position to profit by railroad connection; but it is very seldom that good facilities of that kind can be had where the greatest crowds pass, so this factor is almost always sacrificed to the more important one of securing customers.

16. Financial and Other Considerations.—Many cities, observing that growth comes with manufacturing, offer inducements for new business. These inducements may be in the way of stock subscriptions, remission of taxes for a time, or they may be the more legitimate ones of low permanent tax rate, good streets, water, fire, and sewerage departments, good schools, and housing.

Offers of financial assistance should be carefully scrutinized, as there is too often a string attached in the form of added paid officials who may be found to be hangers on of some town official; or it may be that it is expected that the taxes remitted the first few years will be more than made up in after years by excessive valuation, on account of similar remissions made to other new comers. It should always be borne in mind that every new business coming to a small city or town induces more jealousies than it would in a large place where it might grow unnoticed. The very people who are most anxious to see the town grow are sometimes the first to criticize the new firm for taking the help which "belong" to a concern which was already there.

Often the reason why the town can make great concessions is found to be the possession of a shop building which the people of the town had built for another concern that failed. This building is offered for rent at a figure that will bring back all the money actually subscribed in a very short time. This is a legitimate thing to accept, if the building is adapted to the purpose in view; but if any extensive changes are needed, or any changes that will not be made by the owners, it is a wise thing to weigh very carefully the advantages and disadvantages beforehand. Again, almost any town giving financial assistance will expect to have a representative on the board of directors; and while that seems a very reasonable and moderate request, it is the same thing in many cases as opening the books and all the hopes and ambitions of the company to the entire public.

17. Small Beginnings.—From what has gone before, it seems that it will be wise for a small concern that has hopes of becoming a large one to exist in hired quarters as long as possible without having to make a lease that is of prohibitive length. There are, of course, very decided objections to using other peoples' buildings; for alterations of any moment have to be a matter of agreement with the owners or else be lost completely when the premises are evacuated. However, in the course of the growth of any industry, there usually arrives a time that is very critical, a time when the owners can see nothing but success ahead, but when banks and financiers do not share their hopes. That is the time when the need of enlargement is most apparent to the owners of the business and when it is the hardest to accomplish. Then, if the capital of the company has been kept for machinery and working purposes and is not tied up in buildings, there is a great deal more chance of getting assistance from a distance when the home-town banks will not help at all. There are always opportunities to use money in any growing business, and care should be taken not to tie up too much in land for further expansion, but which may not make any returns for years to come, or in owning mines or mineral deposits to make sure of future materials. All these factors should receive careful consideration and whatever money may be available should be used in such a manner that it will bring the greatest returns in the long run.

BUILDINGS

18. The Purpose of Buildings.—The object of the buildings is to provide a shelter for machinery, equipment, materials in process, men, and finished product. It is necessary that the building shall furnish a suitable foundation for all the equipment, that it shall be convenient for the processes of manufacture, and that it shall be well ventilated, dry, or as dry as the processes demand, and light, if the processes allow it, as they usually do. Any money spent for things in excess of these demands is put into the building for purposes of appearance, or because the bank that holds the mortgage insists on a fine well built building or for some reason apart from production.

19. Permanence.—Building for all time would seem more sensible if it were not for the sorrow with which we contemplate a shop doing business in a building built for all time, even only 30 or 40 years ago. And we cannot be very certain that our own look into the future will be any better than was that of the people who built a short time ago. So many things change, and engineering is going ahead faster now than ever before, that we really can have less confidence than our fathers had as to the future.

TYPES AND METHODS OF CONSTRUCTION

20. Types of Buildings.—For factory purposes, three distinct types of buildings are in use. These are: The single-story building with *saw-tooth roof*, Fig. 1; the *open shed*; with a traveling crane and possibly a gallery on one or both sides, Fig. 2; and the multistory *loft* building, Fig. 3. Each of these types of building has a distinct use, though the work done in a loft building can usually be done in any other type, while that done in either one of the other two types very often could not be done in the others. Hybrids of these types occur, as for example, that shown in Fig. 4, where the lower story of a loft building is made high enough to permit the use of a traveling crane which would ordinarily be installed in the shed; or a monitor section, as in Fig. 5, may be put in between saw-tooth roofs; or a saw-tooth roof may be placed on top of a loft building or on top of the galleries of a shed-type building.

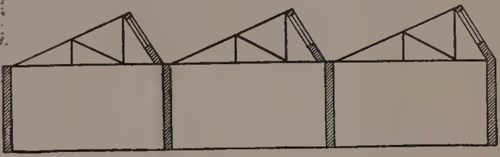

FIG. 1

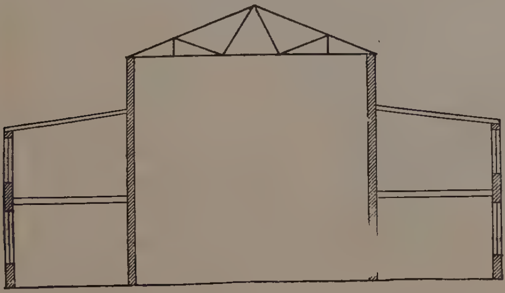

FIG. 2

21. The **saw-tooth-roof building** is adapted only to places where land is available and not so expensive as to make it desirable that area shall be gained by building up into the air. It affords as good a foundation for heavy machinery as can be had anywhere; that is, as good as the land on which it is built affords. It is easily heated, and has another advantage in that it is easily supervised, provided the management does not allow many tool rooms and other partitions to be put in so as to cut the space up into small rooms. It is harder on the superintendent and others who must cover the area, as the distances to be traveled are considerably greater than in the case of the loft building.

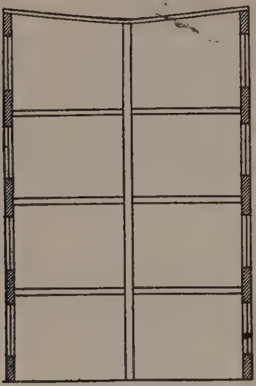

FIG. 3

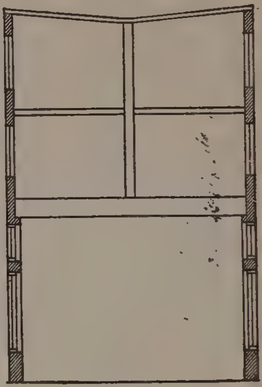

FIG. 4

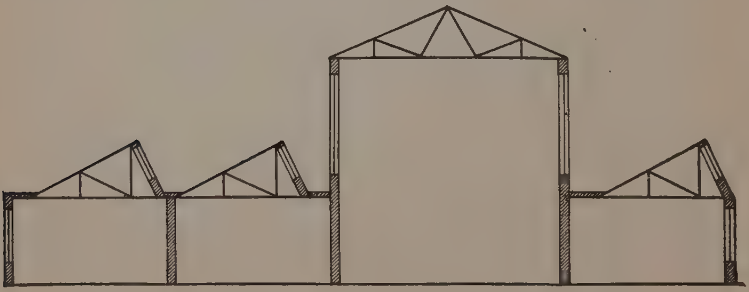

FIG. 5

The saw-tooth-roof shop, all on one floor, gives the most ideal lighting that can be had. It is easily adapted to northern climates by making the lower point of the saw-tooth a large sloping gutter, as shown in Fig. 6, so that there is no danger that water from thawing snow will back up over the level of the bottom of the sloping sash.

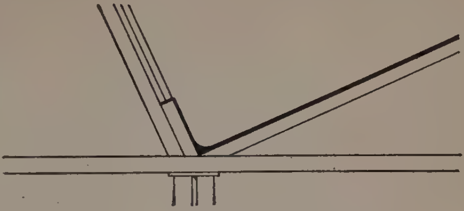

FIG. 6

22. The **shed** gives the largest space with clear room free from posts. Its floor area can be most efficiently used, as very little space for passages need be left for trucking; for most large work is carried overhead by means of traveling cranes. It is a fact that cranes really increase the effective floor space, even as much as 20 per cent. in some cases. However, they do this at the expense of a costly crane that is not always used with good judgment. It is nothing unusual to see several men stand still and watch a 20-ton crane pick up a 50-pound box and carry it up the floor. This is not so inefficient as it may seem; for, if the floor is used to advantage and no space left for trucks, then it may be that this is the only way that the job could be done. The error, if any, was in providing necessity for the removal of a small box from such a floor at all.

The shed type of building is not easy to heat, as the warm air has a tendency to ascend to the peak of the room and leave the workmen cold.

23. The **loft building** is the result of high land values, and is made profitable by the use of elevators. The shortness of the distance from one part of such a building to another is a great advantage in light manufacturing that cannot follow a straight line. For example, as shown in Fig. 3, in the loft building the distance from the center of one floor area to that of the next is only the height of one story, while if the floors were laid side by side on one level, the distance would be the entire width of the building. The loft form of construction therefore saves a great deal of movement of goods in process of manufacture; and as movements by elevator are much more quickly made than are the longer horizontal ones, a considerable saving results if a good freight-elevator service is installed. The loft building is, however, limited as a foundation for machinery. Usually, city ordinances call for a strength of floor to carry about 250 pounds per square foot. This weight includes the machines, the material in process, men working on it, and any emergency load that may be required from time to time. Sometimes the actual strength is made sufficient to carry up to 300 pounds per square foot; but this involves a very heavy building, with many posts that obstruct movement and always seem to come just where a machine or a shaft or a belt should come. The posts on the ground floor take up a great deal of space and obstruct the light just where it can least be spared, as they must be large enough to carry all the floors above them.

Usually, the roof over a loft building is nearly flat. In the city, it is made with a pitch toward the center, as shown in Figs. 3 and 4, where pipes carry the water to the sewer; in the country, the pitch is usually toward the walls. The roof is usually covered with tarred felt and gravel, in a manner that has become standard.

The loft building is the most easily heated of any; for the separate floors can be heated independently, as very little circulation of air takes place through stair wells or elevator shafts.

24. Both the shed and the saw-tooth-roof buildings can be built in a more temporary way than can the loft building. The latter requires heavy posts or bearing walls, as those below have to carry everything above. This strength of walls and posts is the principal reason that the cost per square foot of floor space or per cubic foot of capacity is greater in a loft building than in buildings of the other types. This extra construction cost is partly offset by the fact that a roof the size of one of the floors covers all of them in a loft building, and the area of the foundation is the same regardless of the number of floors. The cost of the foundation increases comparatively little with the number of stories, unless the building is situated where piles have to be driven or where a deeper excavation is necessary for a heavy building than for a light one. The latter condition would exist where a stratum of good gravel is sufficiently firm to carry a single-floor building, but is underlaid by a layer of peat, loam, or other soft material, that would make the erection of a tall building unsafe unless piles were driven or the foundation carried down through the soft material to some solid stratum below.

25. Buildings as Foundation for Machinery.—Some manufacturing requires such light equipment and so little of it that any building that will hold the employes and the materials in process, and keep out wind and rain is sufficient. On the other hand there are lines of manufacturing in which very slight vibration of the building is detrimental to good work of the machines. For example, precision machinery requires a building as near vibration-proof as possible. This quality is not synonymous with strength, for a steel-frame building may have an excess of strength and yet sway appreciably in a wind. A brick, concrete, or stone building will be less apt to show vibration than one with a steel frame. Reinforced concrete seems to be the ideal structural material for loft buildings, because the mass of the building absorbs the vibrations set up by the operation of machinery. It is also possible to make the building as strong as may be desired or to make one portion of it extremely heavy and another part light. However, concrete is not so well adapted to very light construction, and consequently is expensive for the lighter forms of manufacturing buildings. Walls of concrete can hardly be made less than 12 inches in thickness with certainty that the mixture of concrete will be well tamped into the forms, while a great deal of brickwork is laid up in 8-inch thickness only, and wooden walls can be made lighter still. A concrete building, however. is very effective in appearance if built with panels, the interior of each of which is glass with the exception of a thin wall of brick about 3 feet in height at each floor. Such a building can also be made with steel center posts and floor girders and a wooden floor, thus making a light building that has much of the advantage of a concrete building and is less expensive than the lightest all-concrete structure that would be practicable.

26. Floors.—The objections most often raised to concrete floors is that they are cold, that is, that they abstract heat from the men's feet; also, that they are hard and unyielding and tire men more than do the more resilient wooden floors. Just what part of these objections is due to psychological reasons and what part is fact, depends on the men to a great extent. Men accustomed to walking in plowed fields and dirt roads find themselves very tired the first few days they travel on city sidewalks. Also, men who have always been accustomed to walk on brick or granolithic sidewalks find themselves extremely tired at night if they attempt to do as much walking in the country as they do regularly in the city. This is partly because of a difference in the muscles brought into play. The city man develops a very strong muscle down the front of his shin unless he habitually wears rubber heels, in which case this muscle may remain as undeveloped as a farmer's. The farmer has to use the muscles of the calf of his leg much more than the city man does, because he is always climbing up out of furrows or other depressions that he has stepped down into. In the city the farmer has to develop his shin muscles or else buy rubber heels. If every one would wear rubber heels, there would be little complaint about the hardness of concrete floors. The trouble about the cold is undoubtedly real in the cases of people with rather sluggish circulation of the blood, and especially if their work is largely brain work, which causes the blood to flow to the head rather than the feet.

The real test of concrete floors, however, comes not in the number of opinions of prejudiced persons, but in a comparison of the actual labor turnover in plants having concrete floors as against similar plants having wooden floors. This has been tried out, and so far no added labor turnover has been reported on account of concrete floors. In fact, the labor turnover in certain instances that have come under the writer's observation has been less on concrete than on wood. This may be, however, because the concrete buildings, being modern, were so much better lighted, the elevator service was so much better, and in all ways they were so much more desirable to work in, that their general advantages more than offset any objections as to the floors.

27. Wooden floors for loft buildings are very acceptable for moderate loads. They are usually of the so-called *slow-burning* construction with heavy hard-pine timbers, supported on wooden posts of substantial size. The timbers are spaced, usually about 8 feet center to center, and on them are laid 3-inch or 4-inch hard-pine planks with tongue and groove or spline between them, and over the plank a layer of 1-inch flooring, usually maple. Such a floor is resilient and is safe for loads up to 150 or even 200 pounds per square foot. A still stronger floor is made by using 2-inch planks of any desired width laid on edge and each spiked securely to the next.

The top flooring, or wearing floor, may be either square-edged or matched, according to the expected wear or the need for an especially smooth floor. The matched flooring will give much the smoother surface at the beginning; but if there is much wear it is more expensive to cut out a section and relay it than if it were of square-edged stock. The square-edged flooring costs less, as the waste due to the tongue and groove is eliminated and usually a poorer grade of lumber is used. The labor also is less, as the square-edged flooring can be laid without the trouble of driving up each joint.

28. In one-story buildings, concrete floors are very commonly used; though a wooden floor made by bedding hemlock plank in a tar-and-gravel mixture, with the usual maple flooring laid over the plank, will carry very heavy loads, and appears to last almost indefinitely if not subject to floods from time to time. However, at the usual price of lumber it is doubtful whether such a floor costs any less than concrete. When machinery that is too heavy for the floor is to be installed in a one-story building, the ground is excavated at the proper places and concrete foundations of the necessary weight are made.

29. In galleries beside a crane way, floors similar to those described for loft buildings are used, except that, as such floors are almost always used for very light work, they may not be so heavy. The steel-frame construction is cheapest for buildings having a wide span, such as is required by a crane way; therefore, it is customary to carry the steel-frame idea through the side bays, and the wooden floors of the side galleries are usually supported by steel girders or I beams to which 2-inch or 3-inch nailing plates are bolted, and the floor is spiked to them.

30. Construction in Relation to Fire Risk.—In designing any industrial building, the risk of damage by fire should be carefully considered. There are three types of construction, as follows: One, the *slow-burning;* another, the *fireproof;* and the third, the *partly non-inflammable.*

31. The **slow-burning construction** has an outer wall of brick, stone, or concrete, with large window spaces, which may be filled with windows in wooden frames. Wooden floors are laid, as already described, on heavy hard-pine timbers, widely spaced so that there will be no pockets into which it is impossible to throw water in case of fire. The whole construction is inflammable, but the area exposed to the air is so small compared with the bulk of the timbers, that burning proceeds very slowly after a protective coating of charcoal is formed. Such buildings look very bad after a fire; but they usually stand, unless the weight of water held on the floors and added to the load already there is so great as to break them down.

32. Fireproof construction is made up of reinforced concrete, or of steel fully covered with concrete so that none of the metal that might be exposed to the heat of the fire is carrying any weight. Such a building usually has steel window frames, with wired glass on the sides near to other buildings. It can only burn as the contents catch fire; and it requires a long fire and extreme heat to affect the girders unless the concrete covering spalls off the girders which it should protect.

33. The **partly non-inflammable construction,** which is the unprotected steel-frame construction, is very largely used. In case of fire, the steel columns, girders, and trusses assume the most weird and fantastic shapes, the whole thing comes down, and it is an almost total loss, as the cost of cutting up the mass, even with the oxyacetylene torch, is equal to the scrap-iron value. However, this construction is likely to prevail until some practical method of fireproofing trusses is discovered. Such trusses are a necessity over crane runs, and it is necessary that the crane ways be supported on suitable columns. A compromise is often effected by using reinforced-concrete columns for the crane ways or else having the steel columns liberally encased in concrete; but the roof trusses are still left open to fire.

34. How much money should be invested in buildings and how much spent for fire protection and how much for insurance are matters for individual study in each case. If the enterprise is untried, if it is something in which a large present profit is expected and the future is problematic, then a high insurance rate is not necessarily an evidence of poor planning. Only the most stable and settled industries can truly afford the fully fireproof type of building.

35. Sprinkler Systems.—An expedient for reducing the fire risk without adding greatly to the cost, is the use of automatic sprinklers. These deluge the seat of fire with water, and in by far the larger number of cases cut down the fire damage to almost nothing. The water loss is much more likely to be the larger. The expense of installing a complete sprinkler system is much less than the additional cost of building a fireproof plant. The saving in insurance alone will usually justify its installation, and the added security will pay good dividends.

36. Relative Production in Different Types of Buildings.—Certain types of buildings are best suited to certain classes of work. The loft building is adapted to miscellaneous business in which the flow of work is more or less crisscross; that is, work where, though the principal part of the material follows a consistent line from raw material to finished product, many collateral parts have to cross and recross this line. For example, the heaviest casting of an engine lathe may go first to the planers, then to a drill, then to a horizontal boring machine, and then to the erecting floor. There will, however, be other parts, as for example the headstock, which will go to the milling machine, to a drill, to a planer, back to a drill, then to a planer, and finally to the erecting floor. If the shop is a large one, each department may build a portion of the machine and have all the machinery in a straight line to do each job; but ordinarily it is found advantageous in such shops to put all the planers in one group and all of each of the other tools in similar groups, in order to permit of giving each group the expert supervision that brings out the best work. With the last-mentioned arrangement, a certain amount of crossing of lines of flow of work is inevitable, and the loft building is probably best adapted for such conditions; because the total distance to be traveled from any one part to any other part of the building is the minimum, as the elevators make possible a short run from the center of one floor to the center of another.

The saw-tooth-roof shop should ultimately assume, as nearly as practicable, the form of a square, so that the shortest lines of travel may be maintained, not only for the flow of material but of travel for supervision.

The shed type of building with traveling crane is apt to stretch out to a great length, with sometimes three or four cranes on the single long runway. This form is advantageous for the handling of material in shops where everything can travel one way; but the work is hard to supervise, as the lines of travel for every one and everything are up and down the length of the shop.

HEATING AND VENTILATING

37. Methods of Heating.—One of the functions of any industrial building is the protection of the workmen and the materials in process from the weather. The great bulk of all manufacturing, the world over, is done where artificial heat is necessary for a considerable part of the year. Consequently the method of heating is of importance, if for no other reason than that employes look out for themselves so far as possible and try to get into the most comfortable quarters they can for the winter.

The forms of heating most in vogue for shops are: Direct steam or hot water; indirect steam with blower system; forced circulation of hot water.

The direct-steam system at comparatively low pressures is most favored in loft buildings, because by this system it is possible to heat some portions of the building without heating the whole of it, and because the first cost of installation is kept low by the short steam mains, and because there is usually a basement in which the heating apparatus may be installed so that it is possible to use a gravity-return system.

One-story shops are more likely to be heated by the indirect system where the air is warmed by blowing it over a nest of steam coils and then led by means of galvanized ducts to the various parts of the room. These ducts can be carried overhead and be made to discharge either horizontally or obliquely downwards at a sufficient height above the heads of the workmen so that they do not feel a direct current of hot air. When direct steam heat is used in one-story buildings, steam coils are usually arranged along the walls under the windows; but if the shop is large, this arrangement becomes entirely inadequate and it is necessary to resort to coils hung overhead out of the way or else to use a combination with the indirect system just described. When coils and radiators are used in a variety of positions, there is often a great advantage in using one of the so-called *vacuum* systems, where the returns from the radiators are brought together and connected to a vacuum pump, thus increasing the rapidity of circulation of steam without raising the pressure and without making the difference in temperature between the radiators and the room so great as to make the heating inefficient.

Hot water as a heating medium is not often used in shops; it has certain advantages, but the radiators are necessarily large, because the water cannot be safely maintained at much over the boiling point. Sometimes a forced circulation of hot water is resorted to, thus cutting down the cost of installation by allowing smaller pipes and radiators. If the cost of power to run the circulating pump is not too much, then this system of heating is very satisfactory.

38. **Method of Ventilating.**—Heating affects production in some plants where certain uniform temperatures are necessary in order to keep the materials in good workable condition, as for example in the cotton industry; but in general the principal object of heating is to make the shop attractive to the workmen and keep them well and able to continue the work. For this reason, heating should not be considered without taking into account the ventilation. In the great majority of shops the ventilation is dependent on the agreeing of the employes themselves to have the windows open a sufficient amount to give the needed change of air. The result is that the weakest win, and those who declare that they will catch cold if the windows are open even a fraction of an inch, rule; and the windows are closed from fall to summer. Those who suffer from lack of fresh air are seldom so self-assertive as are the sufferers from colds, though in the aggregate the tight closing of the windows undoubtedly causes more suffering than if reasonable ventilation were provided. For this reason, it is desirable to provide means for ventilation that are neither accessible to nor noticeable by the employes.

39. The indirect steam-heat system furnishes a good means of ventilation, and one that is not in any way under the control of the employes, except as some very hardy person

may venture to open a window. The air for circulation is taken from some outdoor source where there is a minimum of dust, and is distributed through the ducts of the heating system. If a comparatively dustless source is not convenient, the air may be run through a washer. Often in cold weather air from the shop is run through the washer and circulated again, thus saving coal. Discretion should be employed in reusing air, as under some conditions the air might contain impurities that would not wash out or it might be impoverished. It has been thought that reused air might show accumulation of bacteria, but experiment appears to indicate that with proper washing such is not the case.

EQUIPMENT

40. Sources and Varieties of Equipment.—Each specific business has its own equipment, so that the subject can be discussed here only in respect to general principles. The purchase of equipment depends on the nature of the business. Since ancient times the blacksmith has been reputed to be the one craftsman who is able to make all his tools himself. Today, however, even though he can make all the tools he needs, he finds that he can earn more money during the time that he would spend making them than it costs to buy them. At the other extreme from the blacksmith, are the various businesses in which no manufacturer expects to take any part in the manufacture of his machinery, and in which it is quite unlikely that he could do much if he wished. Such, for example, is the textile business, in which manufacture is extremely specialized, so that the mill owner buys his looms of one manufacturer, his finishing machinery of another, and so on, but never thinks of such a thing as building them himself.

A great group of industries is supplied with equipment by the machine-tool and wood-working machinery manufacturers. These people supply a definite line of machinery with which any of the usual operations in wood or metal work can be done. They also will build special machinery adapted to the product which their purchaser wishes to make; but often the purchaser of machinery of this kind will have some special machines which are secret, or which he hopes to keep secret, and so he runs a small machine shop of his own, using machine tools for the manufacture of his own special machinery.

Also, there are shops whose work is so specialized that no one else is likely to demand anything similar to it as, for example, the spool and bobbin shops, the manufacturers of horn and celluloid combs, etc. The makers of such goods for the most part buy their equipment from manufacturers who make nothing else and who give each purchaser the benefit of their experience with all the troubles that many shops have had. Occasionally a maker of some such goods will develop ideas of his own and will enter into the job of designing and making his own special machinery; but the shops making such goods are so likely to be small, that this seldom happens. Then there is still another class of manufacturers so specialized in their work that no one can afford to make a business of supplying them with machinery that is at all standardized. These are the makers of newly patented articles that have not yet come into common use and which have not yet incited other people to dodge the patents. Such manufacturers have to design their own machinery and experiment with it until they either stumble on something usable or else enlist the services of some expert designer who sees the opportunity to make a future profit and is willing to do the experimenting. In this class of manufacturers have been the makers of many of the notable inventions that have since become staple products, such as the telephone, wireless, the phonograph, etc.

41. Investment in Equipment.—In the early stages of most small businesses, the simplest and most needed machinery is bought, and for a long time all the surplus that can be squeezed out of the business is spent in getting more and better equipment. There comes a time, however, when the entire question of investment in land, buildings, and equipment has to be considered. Nearly every business does a considerable amount of borrowing from banks. A business concern can borrow moderately from savings banks on its real estate. It can borrow more on a loft building situated in the business district of a large city than it can on any other kind of manufacturing property; it can borrow less on buildings of the shed type with traveling cranes, simply because the bank must look at the value of the building at forced sale. A loft building can be cut up into small rooms and used for many purposes; the other type is useful only for certain kinds of heavy manufacturing. Consequently the pressure from the financial part of the management is to use the loft building whenever possible. However, the equipment must for the most part be owned outright. It is seldom that banks consider the inventory of the machinery and tools as a basis for loans. They want to make their loans, other than those on the buildings, on a basis of quick assets, such as bills receivable and materials in process of production, on which they can realize quickly in case of necessity. As a security, machinery is looked on by banks as likely to be a dead loss. In many cases they are right, because the highly specialized machinery used by many manufacturers is of no interest to their competitors, except as a curiosity. In many lines of business, progress has been so rapid that no one set of machinery has had a chance to wear out before something far superior has come up to take its place. Under such conditions, a user may find it to his advantage not to insist on weight of parts and refinements of workmanship such as would be proper for standard machine tools, since he is likely to find it profitable to throw away his equipment and buy new much oftener than do the machine shops.

From this it will be seen that the amount of money that should be sunk in equipment depends greatly on the rapidity with which invention has proceeded in the past. It is never safe to assume, because great progress has been made, that it has come to an end; for it almost always seems as though the reverse is true. Things that have been much improved in the past are being still more rapidly changed, while things that have stagnated in the past are beginning to show signs of change.

It is desirable to keep these things in mind, because the engineering profession is inclined to look at the present dollars and cents cost of production and often to overlook the loss that must be taken whenever progress demands a change of equipment. Many factory concerns have found their business stagnating because their machinery was built for all time, and was so expensive that when the time came for it to be scrapped they could not see their way clear to take the loss. They did, however, take the loss, sometimes many times over, in the lack of increased production as compared with their competitors.

42. Arrangement of Equipment.—There are two quite dissimilar methods of manufacture, the choice of which is determined by the nature of the goods. One is the **continuous process,** where the product goes along in a straight line, and various operations on it are performed and the product comes out at the further end of the building ready for shipment. This straight line is not necessarily a physical line, and it may have subdivisions or it may have tributaries. For example, in the manufacture of steel wire from the billet to the finished product, there is first the billet mill, in which by repeated passes of the billet back and forth through rolls it is reduced to about 4 inches square. This is then chopped up into about 4-foot lengths and reheated, run through a continuous mill, and comes out as a rod about a quarter of an inch in diameter. It is then shifted to draw benches and drawn down to the desired diameter. It is then ready for shipment, unless it requires galvanizing or some other collateral process. In all of these processes the manufacture has gone ahead; but after the billet mill, the bars may have been distributed to two or more rod mills, and after the rod mills the rods may have been distributed to a number of draw benches, as in each case the billet, which was perhaps 6 feet long, may easily make a hundred miles of small wire.

43. The other principal method is the **intermittent,** or assembly, method. In this, the product is made part by part, or unit by unit, and finally brought together in a completed whole. Some of the parts may be made and stored for a long time; some may be made especially for the particular unit that is to be sold. A notable example of this kind of manufacture is the engine lathe. A great many of the essential parts are small and capable of being made on automatic machines for a very much less cost than if made one by one; such, for example, are the bolts and nuts, capscrews, studs, and gears. These can very easily be made on the interchangeable plan with reasonable tolerances. They may be made in lots of a hundred or a thousand and kept in storage until the time comes when they are needed. The machines on which these parts are made do not stand idle while their product is being used up, but are put to work on other similar parts, so the continuity of operation is broken up. Other parts, like the aprons, feed works, compound rests, etc., are made in quantities of from a dozen up to perhaps fifty, and stored away. Then the large member, the lathe bed, or the ways, is made, sometimes in small lots for the most used lengths, sometimes on single orders for lengths not commonly called for. For example, a manufacturer of 18-inch lathes will usually try to have 8-foot and 10-foot beds in stock ready for shipment, or at least for immediate assembly; but if an order comes for a 14-foot or 16-foot bed, he will have to wait to have a casting made. The final assembly of a lathe of any length consists in putting the bed on to standard stock legs, fitting to it the headstock and tailstock brought from stores, scraping on a carriage and fitting an apron both brought from the stock room; then, while this has been going on, a lead screw and feed-rod have been made, if the machine is of special length, or brought out of stock for the ordinary lengths, and they are fitted; the machine is then tried out and is ready for shipment.

44. A combination of the intermittent and the continuous processes is used to some extent; notably in the manufacture of some motor cars, the sales of which are large enough to justify it. In this case the various parts are made and gradually assembled in something like the outline of a tree

Fig. 7, so that the raw material comes in at each of the tips of branches, has the necessary operations performed on it, and is assembled to the next part at the juncture of the branches. The assembled units are then attached to the main stem where the branches meet the trunk. In this process, the main body of the car, beginning with the frame, or chassis, moves slowly down the shop, and as it passes the opening from each wing of the main building the proper parts to be attached at that point come out from the shop in which they were manufactured and are ready for assembly. The parts from each of these shops, however, may have had a similar method of assembly; for example, the engine has already been assembled by the same process.

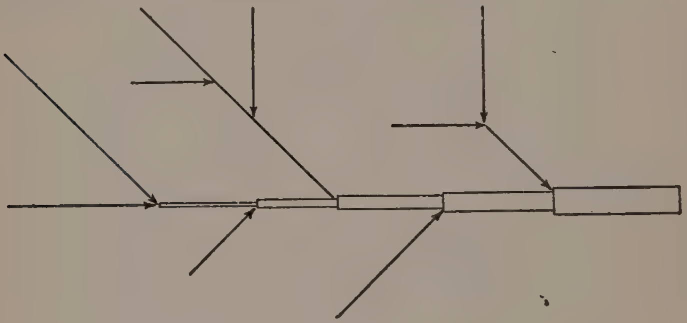

FIG. 7

The advantages of this method is that there is not so much money tied up in idle stock waiting for it to be needed. However, it is obvious that it is applicable only where there is assurance of a very large flow of work, such that the most trivial operation that is performed in the whole works will keep at least one man fully busy. Then other operations become simply matters of keeping a proportionately larger number of men on each individual job. This method has a disadvantage that must be weighed along with its advantages; that is, it discourages progress. Once the shop is arranged to carry out such a method of manufacture, it is very difficult, because expensive, to make any changes in the product.

45. A third form of arrangement of machinery is that of grouping machines of the same kind together. This is an advantage when the work is highly skilled or especially if it requires highly skilled supervision. For example, in a shop that requires a considerable number of gears, it is undoubtedly wiser to put all the gear-cutting machines together, so that the machine best adapted to the particular gear may be used. A complete equipment for a gear-cutting room comprises not only the standard rotary cutter machines for spur and bevel gears, but gear-hobbers and gear-shapers as well as bevel-gear planers. These machines scattered around a large shop become much less efficient than when grouped together with proper facilities for sharpening cutters, etc.

The grouping plan has been carried to the extreme of having all the machines of each different kind grouped by themselves, the product of each being sent to some other machine for the next operation, with the result that in a shop of that kind the routings of the work become an almost inextricable tangle.

46. Both of the intermittent systems require for their success a planning department to route jobs from one place to another and see that they are kept moving. A tangled routing, unless regulated by a planning department, can become very expensive in the increased amount of unfinished parts that are all over the shop. The continuous system of manufacture has the great advantage that there are practically no reservoirs along the way to be kept filled up, but the dams are all down and the stream of work can run along smoothly; whereas, in the other type of manufacture, there are innumerable eddies and backwaters in which material nearly done can stagnate.

There is nothing about the continuous system to prevent advantage being taken of a favorable market to stock up on materials. They simply go into a storehouse much less expensively built than the shop and remain there until required. When a stock is maintained all over the shop, it is mostly in a state of partial manufacture, and has cost something for labor, it occupies space adapted to manufacturing, it is in the way and has to be moved from time to time, all of which is expensive. The best planning department is the one that produces the output demanded with the least value of partly manufactured goods in the shop.

47. Equipment for Handling Materials.—The size of building required for a given production is effected by the equipment for handling materials.

In a loft building, elevators are an absolute necessity; the stairways should be solely for fire escapes, as the elevators should be available for all transportation between floors. The location of the elevators depends on the use which is to be made of the different floors; but, in general, the center of the building is advantageous, as that has the least natural light and the space for the elevators and space for trucks waiting for them is least useful for other purposes. Definite lanes from the elevators to different parts of each floor should be provided and kept clear of all materials except those on moving trucks, otherwise the shop becomes so congested that costs go up on account of delays.

If the center of the floors must remain open, it is better to have the elevators at the center of one of the long sides of the room, as the lines of travel are then only slightly longer than if the elevators are in the center. As a general rule, if there is more than one elevator to serve a building, it is better to group them together; not merely because of economy of installation, but because then, when a man comes with a truck load of materials, he stands a much better chance of catching an elevator going the way he has to go than he does if the elevators are at opposite ends of a floor, in which case he will be likely to find the nearest one going the wrong way or not going at all.

48. Traveling cranes are an absolute necessity for many forms of work, and are therefore not a question of debate; however, there is often a question in regard to the arrangement of buildings served by them, as to whether there should be one very long and narrow building with several cranes all on one runway, or whether there should be several buildings parallel to each other, each having a separate crane, and all connected by a sort of transfer table across one or both ends. The latter arrangement makes possible a shop with less distance for executives to travel, and for the intermittent type of manufacture is much less likely to cause long lines of travel for materials in process. The long shop may be slightly less expensive to build, but it necessitates a transfer of loads from one crane to another if they have to go more than to where the next crane is in use; and this transfer is not much less expensive than the transfer to a transfer table, and then to another crane.

49. Other conveying mechanisms to be reckoned on in the construction of the buildings are tracks for industrial railways, belt conveyers, bucket conveyers for carrying bulk material from floor to floor, the various small, hand-controlled traveling cranes used for light loads and for serving machines, etc. These various mechanisms are made necessary by the methods of manufacture decided on, or else they are a matter of judgment in choosing between a low labor cost and low overhead charges. They are necessarily expensive, but manual labor is both expensive and unsatisfactory. Moreover traveling cranes of whatever type are not subject to especially rapid improvement, and they may be used and sold afterwards without the very great sacrifice that is made with more specialized equipment.

MEMORY HELPS

He who can answer the following questions from memory has a good understanding of the text in the preceding pages.

(1) What is generally considered to be the most advantageous location for a manufacturing plant in relation to the materials used and the customers?

(2) Why is it important to establish a plant fairly near to the large centers of population?

(3) What kind of industries thrive in the country?

(4) In what way does the power supply determine the desirability of the location of an industry?

(5) What is a kind of manufacturing for which good railroad or water transportation is a necessity? (*b*) a kind in which transportation facilities are of comparatively small importance?

(6) Describe the slow-burning construction used for buildings.

(7) For what kind of business is the loft building best adapted?

(8) What are the advantages of the indirect steam-heat system as a means of ventilation?

(9) What is the continuous process of manufacture?

(10) What location is most advantageous for elevators in a loft building?

PRODUCTION ORGANIZATION

(PART 2)

MANUFACTURING

MATERIALS

CONTROL OF MATERIALS

1. Importance of a Dependable Supply of Materials. Control of raw materials of manufacture is important, so important that lack of that control is a constant menace to any firm's solvency. The shop may be so small and insignificant that no one is tempted to put any obstacles in the way of its purchasing whatever it wishes at a price somewhat below the retail market, but much above cost. For example, a small shop may buy its materials all manufactured, and merely assemble the parts, put its own name on the finished product, and market it. This is the way in which many automobiles are made. The engine is bought from one shop, the transmission from another, the body from another, and so on, until the company's own shop has only an equipment consisting of a welding outfit, a few wrenches, and a paint shop. Such a concern, however, is in a rather precarious condition; because the moment it appears to be making a profit there may be an increase in the price of supplies and parts. This increase may be perfectly legitimate; for some of the concerns from whom component parts are bought may

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have given very low prices in order to help the new firm get a footing, and they may feel that it is legitimate for them to get a little larger share of the profits. Also, competitors of the first-mentioned firm are bidding against it and each other for the product of these manufacturers of parts, and the result of this bidding may be unexpected changes of prices that may seriously reduce expected profits.

At the other extreme from the conditions just described is the large concern that owns the original sources from which the principal materials it uses are derived. The United States Steel Corporation, for example, owns coal mines and iron mines, and undoubtedly many other sources of supply for things which it uses in lesser amounts. Such ownership gives them a commanding position in the business.

There are, however, dangers connected with the owning of such resources. For example, a firm using large amounts of copper might own copper mines. Such mines are usually deep and expensive to operate. If, then, their mines were of this nature, and other mines were discovered where equally good ore could be mined with a steam shovel working in an open cut and loading directly into standard-gauge cars, the worth of the deep mines would be reduced.

Also, unless a firm has abundant capital, it is unwise to tie up so much money in such property; for in times when money is scarce, banks are not likely to consider mines to be good collateral for a loan. In fact, it is probable that more firms have failed through trying to cover too much of the range of manufacturing operations than through failure of materials because of lack of their own sources of supply.

It is, of course, easy to show that there must be a profit made at each step of the process of manufacture, and that if all the processes are carried on by one concern, all these profits can be combined. Nevertheless, it must be admitted that specialization makes it possible to make a profit where none would appear to a shop doing all of the operations on the raw material. For example, a concern that makes crank-shafts for many different kinds of automobiles must necessarily get together a body of experience that no one automobile maker could possibly get. Moreover, such a concern can afford to make tests of the billets offered, have specialized machines in its equipment, and take many advantages by which it will be able to make a profit at prices at which no profit whatever would appear if each automobile factory were to make its own.

2. Industrial history appears to bear out the advice to go slow in extending manufacture too far back from the finished product. Every possible precaution should be taken, however, to make business connections so that materials partly manufactured may be obtained regularly, and in such quantity as is needed. This may be accomplished by two means: in one case by beginning manufacture in the plant at one of the accepted stages, so that there will be many sources of supply and numerous bids may be obtained; the other is by making contracts with other firms, and they in turn with others, so that the effect of a continuous supply from the original sources is obtained. This latter arrangement may be made by a system of interlocking directorates, so that each firm that passes along the product of another firm is well represented on the board of the firm from which the product is received. A similar result may sometimes be obtained by personal favor, as in a case where people who are members of the same society, church, or lodge will protect each other for sentimental reasons only.

Another case where the supply of material is assured is that of a firm organized to use the scrap made by a larger company. An example is a small shop making counters, the part of a shoe around the heel, out of the scrap leather produced by a large manufacturer of leather specialties. In this case the small concern is organized within the larger one, possibly with the same officials, and is therefore assured of a supply of materials as long as the large firm exists.

Even when a large firm owns its original sources of supply, it is quite common practice to organize subsidiary companies to conduct certain of the preliminary operations. For example, a large rolling mill may own the majority of the stock of a blast furnace, a railroad, and an iron mine, as well as of other apparently independent companies operating coal mines and coke ovens. In this way all the good effects of complete ownership of the whole plant are secured, with the advantage that in case of stress each plant can go out after outside business. In fact, each plant is usually careful to have some customers in different lines than the next firm in order, so that in time of necessity it can send out a sales force after more business and keep running, even though the company which usually puts the finishing touch on the product may be destitute of orders.

A small shop just starting may lay its plans for expansion, and hope for the time to come when it can snap its fingers at everything except the labor necessary to its success; but at the beginning it may very well conserve its credit by doing the very least possible manufacturing in its own plant, consistent with turning out the distinctive product which its salesmen can present without fear of criticism. An example of such manufacturing is presented in the making of milled screws. The raw material is cold-rolled steel and the product consists of milled screws used to assemble machinery. Cold-rolled steel is made by a multitude of steel mills all over the country, and the screws are used by a much larger multitude of manufacturers. For this reason it is a "safe" business from a banking point of view. Its raw materials are salable in case of stress, and its finished product can always be sold at some price; also, the time between the delivery of the raw material and the delivery of the product is short. In every way the business is a conservative one which will have only a small margin of profit, but which should pay some dividends yearly.

3. Ownership of a Foundry.—In connection with the insuring of a supply of raw materials for manufacture, the question frequently arises as to whether it is advisable for a machine shop to have its own foundry. There are many shops that use iron castings as raw material and buy from foundries; there are also many foundries that turn out castings as a finished product and need these shops as customers. Therefore, it is perfectly natural for one to become the customer of the other. However, in the growth of nearly every machine shop there comes a time when a jealous eye is cast at the profits that are made by the foundry; or friction arises over delivery. Then a foundry is considered, either on the basis of the profit to be made directly, or on the basis of the gain from prompt delivery of castings. In some cases the foundry is built and everything is successful, in other cases the foundry is given up and the loss taken and the old way resumed. The difference may be caused by quite a number of circumstances. It is safe to say, however, that unless both the machine-shop department and the foundry department are independently profitable, the combination is not likely to be kept alive long.

Success in a foundry means the making of suitable castings for less money than is paid or credited for them. Success in the machine shop is rated in similar terms. A company that operates both a foundry and a machine shop has to set a price at which castings shall be credited to the foundry. It may credit them at cost, which leaves the foundry organization with nothing to work for, unless it is to hold their jobs; and that is a most unsatisfactory incentive. If castings are credited to the foundry at the market price, then the only gain resulting to the machine shop from the foundry will be through receiving a better quality of castings. This method is better, for the foundry has the incentive to make a profit at the market and to provide castings of the quality needed for easy machining, strength, or whatever may be required.

4. Where the foundry is credited for castings at the market price, it is very essential to decide in advance what the standard of quality shall be and how it is to be tested. This decision should be reduced to writing and lived up to. No departure from the standard should be allowed unless it is formally agreed upon and reduced to writing. This is equally important with any similar arrangement and is not limited to foundry operation. The most difficulty will be experienced in defining the quality of the castings required. Once the conditions by which the foundry is to be judged are determined, there will be little trouble, as a superintendent who cannot make good under the specifications will resign without waiting to be asked. If a really capable man cannot be found who will accept the conditions under which the arrangement is made, the only thing to do is to give up the foundry or change the specifications.

The most common cause of failure in foundries is lack of suitable equipment. There are many profitable foundries in existence that do not appear to have any worth-while equipment, but that is not a normal condition. To be sure, there is nothing in a foundry that will compare in effect with machine tools, but it is just as essential that a foundry have whatever is necessary as it is for the machine shop. All the sand that goes in a flask has to be rammed, and if the flask is twice as big as it should be, the mold will cost more than it should. If the only flask that is available is too small, there is danger that the sand will fall from the mold when the pattern is drawn. Pneumatic sifters and rammers have become a necessity, and so on, the foundry having by no means been neglected by inventors and engineers.

The quality of the castings is of great importance in any machine shop. They should be soft enough to machine easily and hard enough to wear well. They cannot be strong or hard enough for certain uses and still be soft enough to satisfy the planer foreman; therefore, they should be subjected to definite tests for whichever qualities are most necessary.

Promptness of delivery, especially of emergency castings for repairs or replacements, is of great importance in some kinds of manufacture. However, it is likely that if the cost of this promptness is determined clearly by the cost-accounting system so that it is included in the price, the conditions will be gladly met by the contracting foundry. Of course, a jobbing foundry cannot play favorites in making deliveries unless it can show that it charges a fair price for the accommodation; but if that is shown there is little danger of criticism. It is a fact, however, that it is often necessary for a company to have a foundry of its own for a time in order to learn for itself just how expensive and difficult these special deliveries are.

5. The same principles that have been touched on in connection with a foundry as an adjunct to a machine shop apply equally well to many other side issues in manufacture. They apply to a mill at which it is decided to have a repair shop, to a shop that ships its product in boxes or barrels and starts a box or cooper shop; they apply to the manufacture of dyes in textile factories or inks in printing shops, and to a great many industries.

Too often, factories for making these things are started to show some one else how independent the management can be. Sometimes the provision of such resources and facilities is justified; for example, in a town where the electric light and power company has a history of variable prices, it may pay very well to maintain a steam power plant ready to start up at a moment's notice; or, when a change is made from coal to oil-burning furnaces, it may be wise to preserve the chance to change back very promptly.

PURCHASING OF MATERIALS

6. The Purchasing Agent.—Once it is determined where manufacture will begin, the next step is to make the purchases. In a very small concern this work is naturally placed in the hands of one of the owners, usually the one who makes the most criticism of the others when they attempt it. As the shop grows, this person becomes treasurer, then he hires another man to act as his assistant and take over the buying. This assistant takes the title of purchasing agent, and is immediately studied by firms from whom he might purchase supplies in ordinary times, and his weak and strong points are noted in a thousand card indexes. If he is especially difficult to sell to, he will be used as a try-out by firms who have no hopes of selling him. They send their new salesmen to see him whenever the salesmen show signs of developing a "swelled head." If the purchaser is rated in the indexes as being easy, the "cub salesmen" will be sent to him, with the expectation that they can get just as large orders as any one else. If, however, he is rated as being a sensible and fair-minded man who does not overlook the fact that he is hired for the purpose of saving money for his firm, he will be honored by the visits of the very best men on the selling staffs. There is no place where the old saying, "Nothing succeeds like success," is any more true than in the office of the purchasing agent. The capable buyer attracts the capable salesman. He does not have to spend nearly as much time over his purchases as he would if the mediocre salesman were sent to him, and he secures a great deal of really expert advice for his firm gratis. A purchasing agent who has a good reason for taking one man's product and not another's will usually be willing to state his reasons in such a way that it is profitable for the salesman to listen. Good salesmen know it and act accordingly.

Every firm has need of materials and supplies, some of which may be classified as staples and others as emergencies, or as major needs and minor needs. Those which are both major needs and staples, of course need the most constant and thorough attention. The emergencies may become major demands; for example, in time of expansion into new buildings the purchase of equipment is a very necessary thing, and one in which the purchasing agent may well take a hand, in spite of any detailed knowledge which the engineering department and the works manager may have. On the other hand, a purchasing agent should not spend too much time on the purchase of supplies of small value, if thereby he must slight the purchase of staples.

7. Tabulation of Needs.—It is most necessary that the purchasing agent be able to look ahead. His is more or less of a speculative position no matter what he may wish. If he buys hand to mouth at the market, he may pay a high price for his conservatism or he may save much money, as the case may be, but if he knows how much of a given product he will be sure to need in a year's time, he may be able to secure very decided concessions. Consequently, it is a growing custom among purchasing agents to set a maximum and a minimum for each of the staples that must be purchased. The maximum is the largest amount which the purchasing agent can carry in stock without special approval of the management, the minimum is the amount at which he must take steps to have a new supply coming in. For example, a concern using 12,000 tons of coal per year may decide to carry not over four months' supply and not less than one month's. Then, whenever the amount in the bins, as shown by the stock or stores department, is reduced to 1,000 tons, the purchasing agent must buy, whatever the market; but up to that time, whenever the amount is less than 4,000 tons, he will be on the lookout for bargains, which he will take over whenever he feels that quality and price make it advisable to do so.

This system is applicable even more to smaller supplies. For example, the supply of ink required in the office may have just as definite a range as the coal supply, in fact the purchasing of it may be made entirely automatic, so that the orders may be given by a clerk in the purchaser's office and not have to come to the purchasing agent's attention at all. The same is true of the large number of supplies which may be rated as staples and minor supplies. To care for these, all that is required is that a report be made from the stores department whenever the stock of each article reaches the lower limit. These limits should be set, however, by the purchasing department, as it is necessary to change them from time to time according to deliveries. For example, suppose that a cutlery factory uses grindstones. If transportation is normal it may be possible to make a purchase and get the stones in the store room in two weeks. If the demand for grindstones is great or if transportation is congested, it may be necessary to start the purchasing machinery in motion four weeks ahead of delivery. In that case, instructions might be given to the stores department to report reduction of stock on hand to the purchasing department much sooner, or before the actual number of stones on hand reached the point at which the purchase must be made.

8. Sources of Information.—Many persons think that the duties of the purchasing department are only those of selecting from the goods offered by salesmen. Such buying is of course important, but the man who depends entirely on goods being brought to him must have very great confidence that his firm is well known and that he is in very good favor. For example, a number of years ago there was a firm so unfavorably known all over the eastern part of the country that no salesman went to them with any idea of quoting bottom prices on goods. They were always finding fault and demanding concessions, and yet they were a prosperous and well-financed concern. If they depended only on the price brought them by experienced men on the road, their loss must have been very great. The best purchasers do secure the cooperation of the salesmen, but they also travel freely themselves and make the acquaintance of the people who manufacture the things which they need. Certain supplies are highly technical. The purchaser of inks for a printery, or the purchaser of grinding wheels, has to depend on the reports which are given him by the foremen and workmen in his plant, unless he enlists the services of outside experts. In the case of grinding wheels, for example, he can have an expert come from the factory and demonstrate the possibilities that his wheels have. In this way he is sure that he is not being hoodwinked by some foreman who is receiving favors from some agent for another make of wheel. This only illustrates one of the many ways in which the buyer, in order to protect himself in cases where he cannot be expected to be an expert, enlists the services of others.

9. Testing Materials.—It may be wise in many cases to prepare specifications that require the material to come up to definite tests. Then a testing laboratory may be necessary or else confidential relations must be entered into with some commercial laboratory. It is not always enough to depend on the expert services of a manufacturer or wholesale house. An example of this is shown by the experience of a machine shop when the management wished to make sure that they were purchasing the proper lubricating oils. Everything appeared to be all right with the oil they were using, but another firm had offered oil which they guaranteed to be better and at a lower price. In order to settle the matter, the purchasing agent called for samples from several oil concerns, including the one that offered the new oil and also the one from which he was then buying. The latter told him to take their sample from the stock that he was using, but also offered a new oil at a slightly advanced price, which they said would be found to be worth much more than the extra cost. The oils were all submitted to friction tests at different temperatures, from which it was possible to discover which oil produced the lowest coefficient of friction at the ordinary running heat of around 100 to 110 degrees. It turned out that the worst oil was the new one that was offered by the firm that was regularly supplying the oil. It was not at all suitable at the normal running temperature, but only got into action at upwards of 140 degrees, which was too high for safe working on ordinary shop lubrication. The newly offered oil from outside was but little better, though it began showing a low coefficient at around 130 degrees, while the original oil that was in regular use showed so much better results at the ordinary temperature that it was discovered that the shop could not afford to accept as a gift the new oil offered by the competitor, much less the new oil offered by the firm that already had the contract. Inquiry developed the fact that in making up this latter oil they had added a small amount of very heavy cylinder oil, which was not intended as a lubricant except under steam pressure at upwards of 212 degrees. In this instance the purchaser did a real good to all the parties to the test, as he showed them the results of trials under conditions which approximated those of regular use much more closely than did the viscosity tests and chemical analysis to which they were accustomed.

10. It is becoming more and more customary to buy supplies on specifications and to conduct tests to see that the goods are up to specification. The old guarantees of "best quality goods of good workmanship" have served their purposes and have been relegated to the place where they belong among the uncertainties of the past. No one would think of ordering steel today without specifying the number of points of carbon which it shall have, or, if it is an alloy steel, what the percentage of the various alloys of nickel, vanadium, or whatever is desired, shall be. A great many of the ordinary supplies have not, however, yet been reduced to such a scientific basis that they can be ordered safely purely on specification. For example, leather belting is still very dependent on the selection of the leather by experts who are not able to reduce their own method of selection to rules which can be followed by others. The cutters likewise do their work by virtue of long experience and a knowledge of leather that is almost uncanny. Lumber likewise is graded, but the grading is done by very human men. It is done very rapidly and many times the lumber will go in a different grade at the end of a hard day's work than it would in the morning. In the buying of such materials the purchasing agent can only be guided by the best experience that he can find. He will usually pay quite a little more for his supplies of such nature than he would if he were buying on price alone, but the difference he will charge up to insurance against disappointment when the goods are put into use. A house that does make good selections of material and that will not allow itself to be drawn into price competition, and that can be entirely depended on, is the house from which to buy materials that are difficult to specify, while on goods that can be surely tested and the manufacturers of which know the test to which they will be submitted, it is safe to send out specifications and allow whoever will to bid, care being taken to be sure that the bidder to whom the contract is awarded is able to fill the order.

11. Payment for Supplies.—Every firm has the problem of cash discounts and the problem of inspection, and these are likely to overlap. Goods are billed on the date of shipment, and cash discounts are offered, usually for cash in 10 days from date of the bill. At the time the payment must be made to secure the discount, the goods are still in transit, and there is no check on the quantity or the quality. Dependence then must be placed on the firm from whom the goods are bought to make sure that they are as billed. It is quite the custom to take the discount whenever offered and leave the matter of a final settlement to be taken up after due inspection of the goods. This is not altogether satisfactory to anybody. Once a firm has the money for a shipment of merchandise, it is very hard for them to give it up and make a rebate. They will consequently make a much firmer stand against criticism of the goods than they would if the money had not been received. Cash discounts, however, are very much worth while, as they represent higher interest rates on money than are ever asked by the banks except in times of great money shortage.

ORGANIZATION

12. Form of Organization.—After a supply of labor and materials is made available, and the buildings and equipment are ready, it becomes necessary to organize the production department so that it will run smoothly and do progressive work. In the past, organization has been largely a matter of evolution. One man or two or three partners have begun without any visible organization. Their business has grown, and while each still kept an eye on everything done they each assumed a certain amount of responsibility. Then as they employed minor executives, and, with still further growth, higher executives, they have found themselves obliged to make definite divisions of their own work, lest they put these employes in the position of trying to work for more than one master. There is nothing much more trying than to attempt to work for one of these concerns at a time when the founders are trying to make up their minds whether they are an organization or merely friends doing business together.

13. Line Organization.—When the shop is started by one man, the problem is usually simpler than that just described, though the solution is not necessarily much more satisfactory. One-man control makes for action and prompt action at that, there is never any question whether a decision may be obtained on any point and at once; for the type of man that does not make decisions is not likely to have a growing business. The founder will most surely have what is known as a *line* organization. He will be the head; under him, each in charge of specific things, will be two or three subordinates, probably the superintendent of the shop, the head of the sales, and the bookkeeper, or head of the accounting force. These men will pattern their conduct after that of the owner, each will be a king in his own department, and each will feel free to order the others out of his own particular province if the mood strikes him. They will hold their jobs by virtue of fitting the personality of the owner, and he will be unwilling to discharge them, no matter how independent they become, because they have grown up with him and they fit him as an old shoe fits the foot. This same form of organization is passed along down the line, from which the form takes its name.

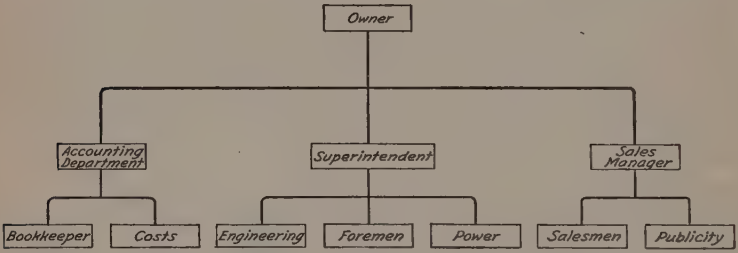


FIG. 1

Fig. 1 indicates the course of authority in a line organization. One advantage of this organization is that it makes one-man control possible over a large business. A notable example of line organization is the army, where each private is under a corporal, the corporals are watched over by the sergeants, and so on. In this form of organization no man can step out of his place without being noted, and mutiny is almost impossible. On the other hand, it is true that the very organization that makes it so easy to maintain discipline also prevents men from becoming of any value except that assigned them by some one higher up. It practically makes it necessary for each person to wait for some one to die in order to obtain promotion.

In a business concern, the line organization is especially apt to bring about internal politics or government by favor. The man at the top, by very virtue of his position, can see but a little way down the line. He knows his immediate subordinates thoroughly, but he is only aware of the existence of the next tier of people, and the workmen themselves are so far removed that his only impression of them is that which remains in his memory since the time when he was a workman himself. If that memory makes him desirous of giving his workmen a fair chance, he has no opportunity to insure that they get it, because his orders go through so many hands that they may be distorted before they reach their destination. As a general rule, each man in such an organization will take the position that he is to be judged by results only, and that the details of how he gets the results are not of any importance to the people higher up. This form of organization is by all odds the hardest in which to do improvement work, whether it be better employe relations, methods of manufacture, handling methods, or what not; because intense jealousies are everywhere present, and every foreman is afraid that he will in some way lose prestige if he allows any one but himself to even know how he conducts his department.

14. Line and Staff Organization.—In the process of evolution, the line organization is likely to find it necessary to introduce experts as advisers to the owners of the business. It may be that these will first be called in for some emergency. As a rule, this practice is not begun except in extreme necessity. It may be that competition is keen and that the firm does not see any way to meet it, so, rather than give up without a struggle, some outside consultant is brought in. If he is successful, he may be asked to make a permanent connection with the company, for fear that he may pass along his acquired knowledge of the business to some other competitor. Once the line is broken by this expert, there is likelihood that more will follow. It seems in some way to be easier for general managers to hire men outright to work under their directions than to go to a consultant and admit that they cannot accomplish what they would like without outside aid. To hire such expert outright is entirely legitimate, until the time comes when the company, having taken from him all that it thinks he can give, casts him aside, thus destroying for him his past efforts at building up a business of his own.

15. The staff may include the engineering department bodily, it may include experts in accounting and in safety engineering; in fact the whole employe-relations group, except the section which actually hires men, may come under the head of staff. Then there is a possibility of a laboratory for the testing of materials bought or the product of the firm, or for experimental work. All of these departments generally report directly to the general manager, except, as will be explained later, in cases where the committee system of control is in force. There are also exceptions in the case of the engineering department, which in many cases is a part of the line organization and is under the works manager. It is an open question whether the design of the company's product should be exclusively in the hands of the production department. It seems that the sales department is in a position to know what the market demands and to know what talking points should be incorporated in the product to make the sales easier. If the engineering department is concerned only with the design of buildings and in providing equipment, there can be little question that it should be directly responsible to the general manager, so that it can have the advice of both the sales and the production departments, but will not be controlled by them.

A laboratory is very likely to be a part of the production department, except as it is engaged in experimental work looking to additional products or to improvements on the old. If the laboratory is for testing the product of the concern, it surely should not be under the production department, but should come at least one stage nearer to the general manager; since, if it is under the production department, it is practically inspecting its own work, and will be subject to all the temptations and influences of the production department.

16. The department dealing with employment and its related work should most surely be under the highest official of the company who is able to give it attention. The office that does the actual hiring of shop employes may well be under the shop superintendent, as it is an executive office and very directly connected with production. But the interviews with the men leaving the shop should not be in any way influenced by the shop organization, nor should the safety work, the medical work, the feeding, the follow-up, or any of the other functions of the personnel departments. These departments must necessarily at times find much to criticise in the production department; but they are seldom placed in a position to do more than make recommendations. Those recommendations, however, will be such as to require executive action on the part of some one else to put them in force; therefore, the departments should be in a position to present their advice to the head of the whole organization and should most assuredly be in a place where they can do their work without interference by the production department.

17. Organization Charts.—There are three varieties of organization charts. The most common form, the strictly *organization* chart, shows the line of authority. The *function* chart shows the functions or duties of the various officials or departments. Another chart is the *flow sheet*, which shows the flow or movement of orders, materials, or ideas in the carrying on of the work.

The first value which these charts have is that they bring before the management in a bird's-eye view just what the "kinks" are that prevent free flow of orders, material, and ideas. Many a firm when confronted with charts showing just what is going on in its plant has cut down the amount of red tape and expedited production thereby. It is often found that many things have to be approved by man after man who has no interest in them, but who does it merely to maintain personal prestige, and by men who sign everything as a matter of course, not even reading what is put before them

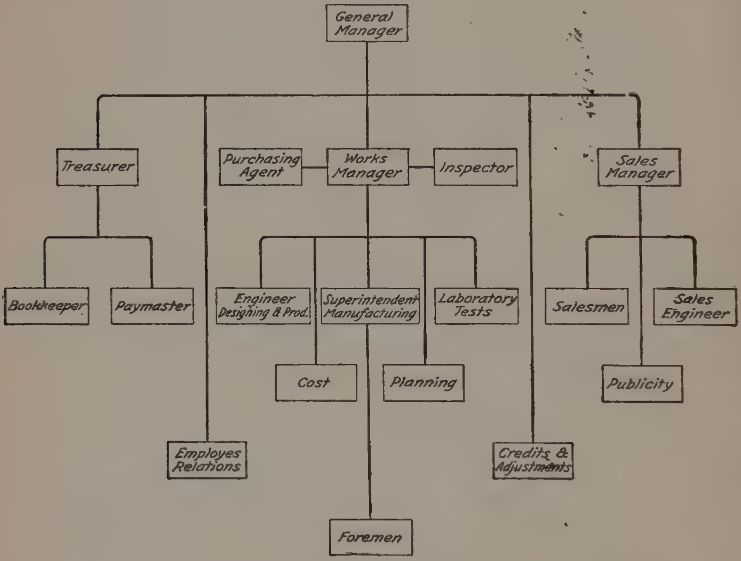
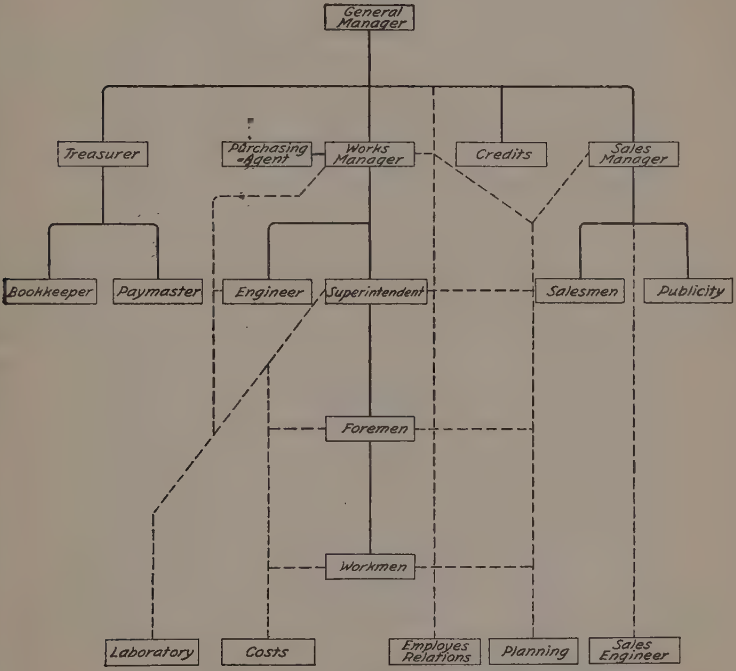


FIG. 2

The one great danger in using these charts is that they will be used and referred to only in defense of some procedure, and that they will be overlooked or overruled in the ordinary course of business. It is not at all unusual to find charts that look well, but which have been so fully superseded that they have ceased to be anything except ornaments on the walls. If kept up to date and respected by every one, including those who are responsible for them, charts are a great help. To a subordinate, they are most necessary, as otherwise he does not know to whom he is responsible for certain things and from whom he should accept orders. Of course a subordinate cannot refuse to do anything required of him by the president of the company, but if he can say, "Will you look out that my superior knows about this and arrange so that he will feel all right about it," then he reminds the president that the latter is stepping out of his own organization to go past a subordinate. Moreover, an organization chart should be available to every one. It should not be a secret, but should be a usable and much-used tool at all times. The time-honored saying that "no man can serve two masters" is forgotten many times a day in some otherwise excellent shops.



Dotted Lines Show Advice.
Full Lines Show Authority.

FIG. 3

18. The functional chart is of the greatest value, though not so often found. Lines of authority are very necessary, but modern business is going less and less by authority and is falling back on common-sense cooperation, and is trying to secure organizations that will function well because men know what part they are supposed to play and where their responsibility begins and where it ends. Whenever a firm that has been in operation for many years draws a truthful chart of the functions performed by its people, there is usually great surprise at the way evolution has twined and twisted things together. Many parallel functions are found exercised by different men, and the same man is found exercising functions of such different nature that a mental gymnast would be required to go from one to another. Most charts exhibit a combination of the line of authority and of function in their make-up, as shown in Fig. 2. A better form for such a chart is shown in Fig. 3, in which authority is shown by full lines and advisory relations by the dotted lines.

19. Flow sheets are a great help, especially to new executives, who are likely to make mistakes that slow down production through ignorance of accepted procedure. A flow sheet illustrating the steps necessary in changing an employe from one department of a shop to another is shown in Fig. 4.

Flow sheets are applicable to the movement of material from the time it enters the shop until it is assembled and shipped out; they are also applicable for small steps in the process, for the flow of ideas from the shop back to the office, for procedure in getting out circulars descriptive of the work and product, for the making, acceptance, and execution of new designs, and for every purpose where more than two men have to cooperate in accomplishing anything. There is no need of making flow sheets for every instance; but the moment any question arises regarding a division of responsibility, or an executive finds himself unable to decide to whom he should send anything for the next step, a flow sheet should be made and adhered to.

20. Division of Functions.—There are only a limited number of minds that are capable of handling accounting that are also mechanical; even fewer that are mechanical also have executive ability, though there are more that combine executive ability with accounting. Then there is the type of mind that sees things from the sales point, that is, from a detached position, as through the customer's eye rather than its own, and that ability is seldom found combined with any of the other types of executive. In general, the functional organization of an industry should be such as to allow the individuals who are available to take upon themselves the duties which are most congenial and in which they have the greatest ability; however, it is seldom that a large organization does not find itself obliged to place some man in a position for which he is not adapted by nature or temperament. For example, a firm may find that it has two men equally capable as traffic managers and none that is above par as head of the stores department. It may be necessary to place one of the two traffic managers in the stores department, even though

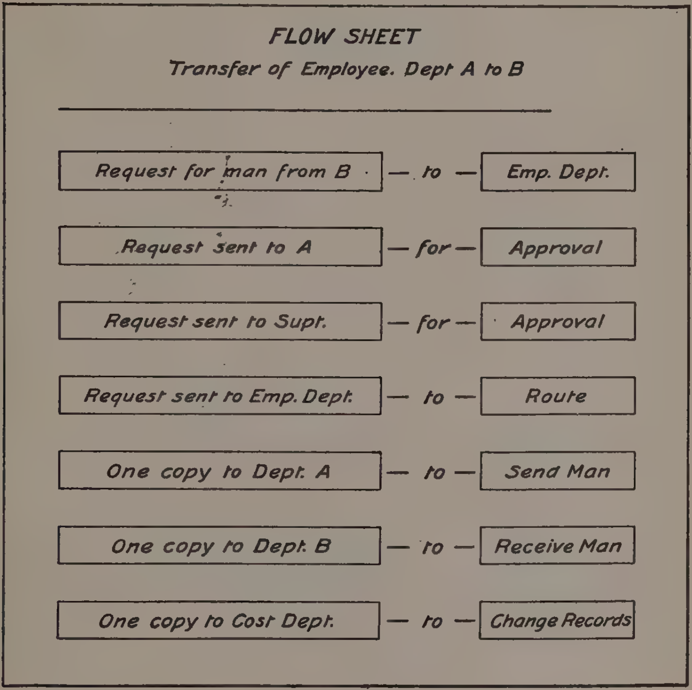

FLOW SHEET
Transfer of Employee. Dept A to B
Request for man from B — to — Emp. Dept.
Request sent to A — for — Approval
Request sent to Supt. — for — Approval
Request sent to Emp. Dept. — to — Route
One copy to Dept. A — to — Send Man
One copy to Dept. B — to — Receive Man
One copy to Cost Dept. — to — Change Records

FIG. 4

that may not be the best place for him, and to pay him a salary commensurate with his ability, even though a good store keeper might be found for less money. The safety in having a man who can step into the traffic department is worth the extra cost of keeping the other man in stores. These conditions are found in nearly every large plant in some place or another.

Functions naturally divide into the large groups, such as production, sales, accounting, and so on. Sometimes a good salesman and a good production man are found in the same person, and sometimes a good accountant may make a good salesman, but very seldom does a good accountant have any desire or ability to get into the shop. Shop men are constantly wanting to get on the road, and in highly technical industries they are likely to make good. This distribution of ability makes it quite desirable that the time-keeping department, the clerical people in the stores and the stock departments, and similar employes in the planning and cost departments should be under the direction of an accountant. This is not a usual division, as these departments are quite likely to be under the works manager, if not under the superintendent himself. It so seldom happens that a man who is suited by training or temperament to the superintendency of a plant is at home in even these simple forms of accounting, that the real control of such work is usually found in the accounting department, even though the men who do the work are nominally under the control of the shop man.

21. It is a very common thing to find a superintendent who maintains that, in order to keep up discipline and maintain his authority, it is necessary that everything inside the shop limits shall be under his absolute control. He considers himself responsible for production, and reasons that he cannot be held responsible for that which he cannot control. There is enough truth in his reasoning so that it is worthy of consideration. If the organization does hold him personally responsible and washes its hands of all its responsibility, then he may be right; but he has assumed a place that any man should consider deeply before he takes it; for if he is literally without the support of the rest of the organization, he is likely to lose his job whenever business conditions which he cannot control, and only the sales department can influence, make business in general poor. If, on the other hand, he expects the hearty cooperation of the other departments in both good and poor business conditions, then he ought to concede the necessity of their having a constant knowledge and check on what his department is doing.

Whether the stock department, the planning, and the shop-order departments shall be under the superintendent, the works manager, or the general manager, is governed by the way the firm is organized as to this cooperation or lack of it. Planning, as will be explained later, is something that is technical, so far as executive work is concerned; engineering, so far as the future is concerned; and accounting, as to its records. For this reason it would seem wise to place planning under the executive who controls all three of these departments, who in some cases is the works manager, more frequently the general manager, but seldom the superintendent.

22. The finished-stock department likewise comprises distinct functions within itself. It may easily be technical in such shops as make products used in engineering. Thus, in the manufacture of grinding wheels the stock room becomes of great importance, owing to the great variety and range of wheels required; and the stock keepers have to know which wheels will be considered interchangeable in different parts of the country and for different machines. For example, an order for wheels for saw gumming from Alabama requires quite a different wheel from an exactly similar order from Oregon, owing to differences in lumber sawed and also to customs. However, any well-organized stock room maintains a perpetual inventory, which is really an accounting function. Moreover, the sales department has a vital interest in seeing that stocks are maintained of salable goods that may become emergency goods under certain conditions. A manufacturer of farm implements knows that weather conditions, which he cannot predict, may make a considerable difference in the number of sprinklers required for spraying Paris green on potatoes, and that the rush demand, if it comes at all, will be at a certain definite season, and that if the shop gets two or three weeks behind its schedule it may make a great difference in the profits from the sale of such apparatus.

The order department may appear to be distinctly a sales department affair, but the shop may have a very large interest in the way orders are divided up into shop orders. A rubber-shoe factory may have lasts for so many thousand shoes of certain sizes, and will want its orders to come in multiples of that unit rather than exactly as the order comes from a customer. But, the sales department knows the conditions, so that it can best say in what sequence the different parts of the order shall be delivered, and knows whether in order to retain customers it may be advisable to make the shop cost slightly larger by splitting an order and letting a smaller order come through between the parts of the larger one.

23. Cooperation.—From the foregoing it will be seen that it is virtually impossible for any department to take its stand entirely independent of the rest, but that full cooperation is necessary to secure the greatest profit possible. Habit has in many industries made the manufacturing department very much averse to so-called interference, but this attitude has often been changed by resort to the committee system, as explained later, which softens the blow that the production department feels has been dealt it when any of its privileges are taken away. This method appears to be a very good one, because in a committee conference in which the superintendent meets the sales manager and the accountant face to face with the general manager, the superintendent realizes that he is outnumbered and that he must present not statements alone, but arguments. The question of discipline under divided responsibility is a grave one, but not so vital as many superintendents think. As a matter of fact there is no such thing as discipline possible in a shop, in the sense in which the word is commonly understood. No punishment of an employe for violation of rules is possible. Once hired, he must be paid according to the agreement so long as he is retained on the pay roll. Of course, the law is infringed at times, but for the most part employes are fully aware of their rights and insist on them. During good times, it is not usually a loss to a man to be dismissed from a job. During dull times, no one takes the chance of being dismissed for reasons of discipline, unless he wishes to sever his connection with the company more than he wants the job. He may try breaking rules to see if the company really means them, but he only does it because he does not care much for the job itself under the rules which govern it.

24. Committees to Aid Cooperation.—Corporations that are an outgrowth of a family concern are very likely to make considerable use of the committee system. In such a case, instead of some one man's assuming authority and making a decision, that might hurt the feelings of some one else whose good opinion is of more importance than dividends, the matter is taken up by a committee in which all interested in the matter are represented. For example, it may be that the heads of such a company are not agreed as to the best way to handle transportation of employes. Instead of allotting the matter to one man, a committee is formed in which all who have differing ideas are represented and that committee calls in every one whom it feels might have suggestions of value, a vote is taken and everybody feels good natured about it. However, the process is so slow that, while the committee is coming to a decision, one man with the requisite authority might have the whole plan in operation and be at something else.

There can be no doubt that the plan of doing business by committee conferences is slow, but it is in line with the advancing wave of democracy in business, and probably will increase rather than retrograde. The present tendency is toward committees to decide on policies that are to be put in execution by individuals, in which case the committee becomes a functionalized part of the staff, advising the general manager what to do before he issues orders for the line officials to carry through. These committees may be formed at will for the solution of any perplexing matter or any matter in which there is not unanimity among those in control.

25. Shop Committees.—In some industries, shop committees are finding a place in the business organization. These have usually been started to offset union activities, but in many places they have functions quite different from those relating purely to wages and hours of labor.

The theory of the shop committee is precisely that of the committee of the management, a plan to assist in smoothing out things where personal jealousies might make a rupture. The shop committee can hardly have executive functions and thrive. It must from its very nature be advisory, but its advice is so publicly known that it can hardly be turned down unless there is a desire to precipitate a quarrel.

The course of shop committees however seems to be rather uncertain. When they are first formed, there is considerable enthusiasm. After a little time they may turn in several directions; they may resolve themselves into grievance committees and, after they have achieved all that is reasonable, may begin to be captious and stick at very small points. The management gets impatient at their narrow point of view and abolishes them entirely. Or they may become political, and men may resort to the same methods used in ward politics to secure nomination and membership in the committee, and then they may secure advantages by impressing their constituents with the value of what they have done. In any case, the members of the shop committee are not in an enviable position, as they have to compromise among themselves and with the management in order to accomplish any good at all, and then they have to explain to the workmen how it happens that they have not accomplished what was desired.

Some committees have been formed with the express restriction that they shall not discuss wages and hours, but shall act for the purpose of promoting athletics or entertainments or aiding the sick or for some purpose not always uppermost in the minds of the employes. However, to form a committee with such restrictions is unwise, because no power whatever can prevent them from considering these things, and if no attention is paid to their requests, the management is deemed antagonistic to them and to the employes. The one thing that cannot be barred is discussion of wages. To try to prevent it is comparable to gathering the sales department for a conference and trying not to mention prices.

26. The method of selection of representatives on committees varies in different concerns. In some, the workmen all assemble without any of the management present and vote for their representatives in open meeting, very much like a town meeting; in others they vote by the Australian ballot and each man's vote is a complete secret unless he sees fit to announce it. In some cases the whole shop will vote for delegates at large, and in others each room or department will vote for an allotted number of representatives. In some cases the representatives who form the council that deals with the management are elected directly by the workmen, in others the body which is elected by the workmen elects still another body; and in some cases this last-mentioned body elects a very small executive committee which handles nearly all matters without referring them back to the larger committee. In one shop, the final executive committee meets by itself and sends resolutions to the management, in another the executive committee is met by an equal number of persons selected by the management and a joint meeting is held, the votes of which are considered by the management then and there. Every possible combination of these elements is in process of being tried out somewhere. The whole system of shop committees is in process of development, and only experience can show what methods of dealing with them are best.

From the employe's point of view the secret ballot in connection with the election and operation of shop committees is undoubtedly very necessary. Some men resent having even so much restriction put on them, and declare that any one who is not man enough to vote where every one can see what he is doing should not vote at all. Nevertheless, the secret ballot undoubtedly cuts down the amount of time spent in electioneering about the shop, with the attendant loss of production for some days or weeks prior to the election.

27. The committee offers very distinct advantages from the employer's point of view in furnishing a small body of people with whom to deal. It is, however, difficult to get suitable representation of different parts of the shop with a small committee. For example, in a small shop there may be a large number of woodworkers and a small number of yard men, machinists in the repair shop, blacksmiths, rubber workers, coopers, and so on. The work of all these men is necessary, their trades are quite different from the woodworkers, and it is practically impossible to get a truly representative committee unless there are enough members so that the trade having the smallest number of employes has one representative and each other trade has representatives in proportion to its numbers. An expedient that has been used is to elect this large committee and then for that committee to elect, from its own number in some cases and in others without restriction, a smaller committee which is intended to represent the whole shop. This plan has the difficulty that the smaller committee may very likely have on it no representatives of the trades that have but few employes.

It is not at all easy for a woodworker to understand the troubles of a blacksmith nor to see why he needs suitable equipment nor to understand what is suitable. This same lack of understanding is likely to be found wherever the shop contains a minority of highly skilled workmen whose work is, however, essential to the continuation of the work of the majority. The shop committee in such a case transfers the need of an understanding from the employer to the shop committee. Experience so far indicates less tolerance on the part of one body of workmen for another than that existing on the part of employers toward these same men. The best that can be done seems to be to insist that at least one representative of one of the minority trades be on every committee that sits with the management. Of course insistence by the management on the make-up of committees does not make for a pure democracy, but that perhaps is not of great importance.

28. In the deliberations of the large committee elected by the workmen themselves, it does not appear that the management is even represented, in many cases, though they are expected to provide the room, the time, and the equipment. This is undoubtedly a wise provision; for if nominations are made from the floor there will undoubtedly be many speeches made that would be enlightening to the management, but which would not make for further good relations. The executive committee, when there is one, is very likely to have its principal deliberations in private and to appear in meetings with the management only after the committee have united on a policy, which is as it should be for the good of both parties.

The test of time alone will tell to just what extent the whole number of employes care about this representation by committee. In the meantime it appears wise, though it is not often mentioned, to insist that a majority constitute a quorum and that no vote by a smaller number shall be considered carried. It is customary, also, to make a certain length of service a qualification both for voting and for holding office. The length of time in the company's employ to entitle an employe to vote is placed all the way from one month to a year, while the employes who hold office must have been in the company's employ from 6 months to 2 years. It seems reasonable to let employes vote for their representatives as soon as it seems likely that they intend to remain, and that the officers should be chosen from among men who have been with the company long enough so that they are well acquainted with its methods, which is seldom less than a year. It has been suggested, but not so far put into effect, that every new employe should pass over one election after he is hired before he is allowed to vote. This is suggested as a means to prevent important offices from being filled with the friends of some group of men who do not intend to stay and who may possibly not even have severed their connections with the firm for which they worked before.

Perhaps the things most to be feared in connection with the committees are a total loss of interest on the part of the employes who might be of the greatest assistance to the firm, and the danger that men will be elected as representatives on account of their social qualities rather than because of their ability to represent truly the men who elect them. If the employes elect men for such reasons, they will only be following the precedent established in the past century of this republic, where there has been a strong tendency to elect representatives and senators because of qualities that have little relation to their administrative abilities.

DESIGN OF PRODUCT

29. Who Should Control the Design?—If the company is a one-man concern there is no doubt as to the man who shall control the designs; it is the one man, of course. If, however, the company is made up of men who are practically in partnership, there is danger of friction over the designing. If the company is virtually in the hands of its general manager with an absent board of directors who are only interested in dividends, another set of influences may determine the work of the designing department.

The question of who should control designs depends, likewise, a great deal on the nature of the product. If it is wallpaper or automobile bodies, it may be that the sales department may properly have the greatest say, because sales depend on suiting the taste of that part of the public that is being catered to; but if the product is automobile engines, electric motors, or machine tools, the engineering department should have the say, subject to consideration of the manufacturing difficulties which the shop may discover on inspection of the drawings. In all these cases, it is vital to remember that the product must be sold as well as manufactured, and that sales may sometimes be more easily made by making production costs higher. If "talking points" will save the company more than they cost, then they are certainly worth while. For example, in almost every new product there is an evolution from incompleteness to completeness. The automobile and the phonograph began with comparatively simple things that were very incomplete from our point of view today. The automobile of 20 years ago needed head and tail lights, horn, wind shield, and other devices. The phonograph has grown in completeness in the same way. These all cost more to produce than they might without certain refinements, but the customer gladly pays the bill, for he now knows that when he has bought any of these things he has something complete, and that he will not have repeatedly to go down in his pocket for necessary extras.

Questions in regard to such things are properly determined by the sales department; for that department is in touch with the customer and knows whether the public will pay enough more for all these extras to make it profitable to furnish them, or whether such things will enable the sales force to make sales for enough less cost so that they will be profitable, or, in other cases, whether the fact that some competitor offers a complete machine ready for use has made it necessary to make a similar offer with little regard to whether it is more profitable or not.

30. Design as Related to Production.—From a purely production point of view, differences in design may make very considerable differences in cost. As a general rule, the designing department is likely to look out for things that do not so much appeal to either the sales or the production department as to engineering. Perfection of mechanical operation of machinery is a natural thing for an engineer to place above cost or selling points. In some important manufactures it is the most important. If the product is scientific instruments, then mechanical perfection is everything. If it is wheelbarrows, then it is best to let well enough alone, for added mechanical perfection will not be appreciated nor paid for.

Certain things however are strictly in the province of the drafting room or engineering department, for, within the limitations specified by the sales department and the production department, they still have the problem of designing parts so that they can be readily made and equally readily assembled and disassembled. The ease of production of parts is likely to receive much the greater attention, more than it really deserves; for money spent on the erecting floor adds to the cost just as does money spent in preliminary operations.

31. Design of Parts.—A concern that makes nothing but steel wire nails has no problem of design, because it cannot depart from established standards of the trade. A concern that is building machine tools is under the necessity of making its machinery sufficiently distinctive so that it will not be scornfully referred to as a copy of some other manufacturer's machine. Manufacturers of automobiles must make their cars sufficiently different from all others so that they may be instantly recognized from some distance, for advertising purposes. Yet in all these cases there are considerations of design that can make the difference between a profit and a loss. In the case of wire nails, the very slightest difference in the shape of the head may have a considerable influence on the length of time the dies will wear or on the ease with which they let go after the head is upset. In the machine tool, there are numerous parts that perform important functions, but which are never seen by the purchaser unless in case of a breakdown. In the automobile, the same holds true. So far as these things are concerned, then, the engineering department should, after providing for strength and mechanical perfection of the degree needed for successful use, consult the shop as to the form and material of details that will make manufacture economical.

For example, consider the use of standard parts. If, in the case of an automobile, it is possible to buy all nuts, bolts, screws, and washers from standard stock, there is not only a saving for the manufacturer, but there is a great convenience to the purchaser. The idea that it should be made necessary for a purchaser to send to the factory for trivial repair parts has been shown to be erroneous. A cabinetmaker who specifies sizes of glass a trifle larger than standard sizes makes his firm pay for the next larger size with no salvage. Tubing can be obtained in so many sizes and thicknesses of wall, that it should not be necessary to create new sizes; and yet special sizes are being called for all the time.

32. Within the shop itself, standardization is not only possible but profitable. If, for example, the company manufactures a line of woodworking machinery, it is possible to use the same parts on different sizes of machines. The parts may be unnecessarily heavy and strong for the smaller machine, but the labor cost is so much reduced by making lots twice as large that the difference in cost of material is much more than made up. A manufacturer of engine lathes can use aprons of the same size on both an 18-inch and a 20-inch lathe, and the same on a 14-inch and a 16-inch, and make a profit by so doing. There is especial advantage in using as many gears of the same size as possible, for a very considerable gain comes from so doing. Also, parts of the same kind that can be made to advantage on a screw machine or a turret lathe should be used on as many machines as conditions permit, for the reason that the cost of screw-machine products decreases rapidly as the lots are made larger and the cost of setting up the machine is distributed over a larger number of similar parts.

33. Selection of materials is also of great importance. In making machinery it is often the case that ordinary soft steel is amply strong and otherwise fit for the purpose, but that it will pay to buy a higher grade of steel for the sake of the greater ease of machining. For example, if the part has screw threads, it is wise to use steel of at least 25 to 30 points carbon (that is, .25 to .30 of 1 per cent.); as the tools last longer, and they do not require to be kept to as keen an edge as is necessary in order not to tear the material and spoil the job if low-grade steel is used. If the work is straight, like rollers or shafts, and it is to be ground for the final finish, there is no great difficulty in using the low-grade steel; but if the work has any outlines that must be formed to a curve or if screw threads or channels are to be made, it is profitable to use the harder stock, as it can be finished well with ordinary cutting tools. Such instances multiply and make necessary the careful study of materials in the engineering department, a thing that often is not done. It is even true that parts ordinarily made from castings can often be more cheaply made on the screw machine from cold-rolled stock. Castings themselves can be annealed, and thus a great deal of the cost of machining will be saved as well as cost of tools used and worn out. Also the internal stresses in the castings will be eliminated. The practice of annealing is, however, confined almost entirely to shops like those of manufacturers of textile machinery which have great numbers of small parts that can be annealed at once. However, an annealing furnace is not expensive and in these days of gas requires little attention.

34. Design for Easy Machining.—Particularly in the manufacture of machinery, there is great possibility of saving money by adapting the parts to easy machining. There should be a constant balancing of the advantage of making parts in one piece and of making them separately and fastening them together. If parts are made in one piece, alinements that are necessary are guaranteed except for wear. However, it may be very much cheaper to make them in separate parts and bolt them together. If, when bolted up and sufficiently dowelled, they cannot be disturbed so far as alinement is concerned, then it is surely wise to make them that way, unless the appearance of the product is against it. Some designers seem to have a mania for making their machines, as they say, "in the foundry," casting as much in one piece as possible. This is not only expensive in the foundry, but it often may make the total cost very high, indeed. For example, suppose that a part is to be made which comprises brackets carrying a slender shaft and that there are three or more brackets, as in Fig. 5. In order to secure correct alinement of these bearings it is necessary either to babbit the shaft in place or else to bore the holes with a long slender boring bar with which only a very light chip can be taken at a very fine feed. Even then, the final reaming of the hole is likely either to throw it slightly out of line or else to produce fine chatter marks.

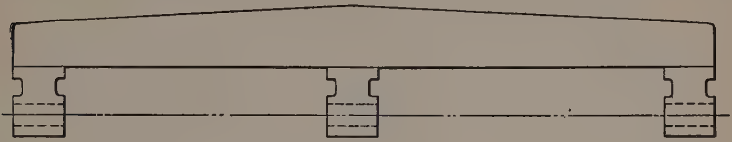


FIG. 5

Another common source of high costs is due to designs that are awkward to machine. For example, Fig. 6 shows the cross-section of a slide with a projecting arm in such a position that it is almost hopeless to attempt to machine it at all. It can be done by using two cutting tools, one of which will reach part way down the right-hand bevel and the other the rest of the way, and doing the job on a planer. The piece can, however, be reduced to a milling-machine job by making it in two parts.

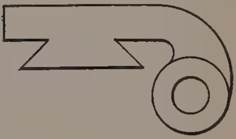


FIG. 6

35. Design for Long Life.—Certain manufactured products are articles of consumption and are not efficient unless used up, as, for example, grinding wheels, milling cutters, and similar articles. Long life in such a case means simply life as related to effective working. It is always wise to buy grinding wheels that will cut freely, rather than those that merely glaze over and yet last a long time. With milling cutters, long life means retention of a fine cutting edge for a considerable time. On the other hand, steam engines are ordinarily used for many years. They require expensive foundations, and the installation expenses are heavy. Consequently, they are designed to last for as long a time as possible. The cylinders are made heavy enough so that they can be rebored several times without becoming weak. The various bearings are all made with provisions for wear. To be sure, the recent advances in the manufacture of steam turbines have caused the stopping of many reciprocating engines that were designed to run for a long time to come, but that is one of the freaks of progress that should always be expected, but which seldom comes. Textile machinery affords an excellent example of temporary design, as does also envelope and box machinery, and, to a lesser extent, printing machines. All of these have a history of constant advance, so much so that a machine 10 years old is pretty well discounted by the machines that have been put on the market since. Consequently there is not much reason for assuming that the future will be different from the past, and it hardly pays to put more money into such machines than at present. The result is that looms and other textile machines are crude in appearance and workmanship as compared with some other kinds of machinery. However, they fulfil their need, they last until something better is invented and placed on the market, and consequently there is no good reason for discarding them for lack of refinement or for making them any more expensive for the sake of longer life.

Printing presses have to be much more accurate in their movements than do textile machines, and yet they are not of the extreme refinement that is expected of precision machine tools or telescope mountings and the like. The latter, perhaps, represent the extreme of refinement, high cost, and long life. It is never expected that a telescope and its mountings will ever be entirely discarded or rebuilt. When a new and larger telescope is built the old one is still kept in commission and used for such work as it can do well.

36. Design for Long Sale Without Change.—A notable example of the use of a design without change is the Ford car. Where other manufacturers have brought out a new model every year, Ford has clung to the same car, and with the exception of a slightly less offensive style of hood and a few other minor changes it is the same as when it first began to acquire nicknames. There are many other kinds of machinery, notably in the machine-tool field, that have maintained a place on the market for even longer periods without change of design, but they have not been so much in the public eye.

The requisite for keeping on sale without change is a mingling of conservatism with being ahead of the times, and with an entirely definite honesty of design and materials that is seldom possible. In the march of progress, there are always certain underlying principles that must be taken into account by the designer. If the machine is designed according to these principles and it does not break down and give trouble, it is almost certain to find some sale at all times. But, besides the qualities mentioned, it must in some way be ahead of the times when it is launched. If the principles are good, however, it is possible to sell things which are ahead of the times. When the Ford car was brought out, the public were still accustomed to see the old style of Oldsmobile with the little curved dash that reminded one of the still older-fashioned ice skates. The Oldsmobile, however, paved the way for a car which had the engine under a hood in front, instead of a single-cylinder engine under the seat, and also for a four-cylinder engine, which at that time was comparatively new but was sufficiently tried so that its success was certain. The use of these innovations by Ford was enough to place his car ahead of the times, but not sufficiently so but that the builder could keep up with his orders. Later, after other low-price cars outstripped his in appearance and comfortable riding, the fact of its dependability came to be an important thing. Exactly similar things have made it possible to continue certain machine tools on the market for 20 years with very little change. First, there has been a distinct advance over current practice, then an up-hill period during which sales have been hard to make, but satisfactory. Then a period during which competitors have perhaps created better designs, but have not maintained the quality of workmanship or material that has been held to by the original maker.

37. Design for Quick Delivery.—Certain products may be produced rapidly in emergencies, but there may not be sufficient margin of profit in them to justify the carrying of large stocks, or the prevailing styles may be likely to change overnight. For example, farm machinery is not likely to be ordered by the consumer until needed. He has no very great amount of loose capital, in fact he very likely has to go to his bank and discount his note to get the cash at all. He wants the machine delivered at once. Consequently, while agricultural-implement factories run the year around, they run the fastest when the demand is greatest. The latter statement is true of things that are subject to change in fashions, like clothing, hats, and so on.

In many cases the designer cannot change styles, but he can often meet the needs by designing methods of rapid production. The World War gave a wonderful opportunity for the doing of just this thing. Where previously it was expected that somewhere around three years would be given to designing and making tools and fixtures for any but the simplest product, during the war it was found possible to use machines such as flat turret lathes to do a great deal of effective interchangeable work that would ordinarily be put on automatic screw machines, and also to do a great deal of milling-machine and planer work without waiting for expensive jigs and fixtures, by making changes in the design which made it easier to hold the castings which were to be machined.

38. General Considerations in Design of Product. Because there are so many things to be thought of when designing machinery or any manufactured product that is open to variation, design should not be the function of one of the major departments alone. As a rule, a draftsman, or designer, is more likely to have the purely mechanical use of the finished product in his mind than any other, and he is, consequently, likely to resent what he deems interference, if the other departments take a hand in his results or if they ask pointed questions. The only way to avoid ill-feeling over designs is to secure draftsmen who realize that for their own good they should seek out all the information possible before they are asked to take advice. It seems natural for one to wish to get the benefit of all available experience, but there are many draftsmen who fear that their standing in the eyes of the management will be lowered if they admit that there is any one in the employ of the firm who is capable of giving them any help. In such cases, criticism by a committee is likely to work out well, because then there is not so much chance to become personal. Of course, if the chairman of the committee allows members to make direct statements to the effect that the designer is a fool, there is more danger in the committee than without it; but it is presumed that a chairman is for the purpose of making the meeting impersonal. The effect of criticism of designs and criticism of persons is very different, especially if the designer is inclined, as so many are, to be temperamental.

39. Design of Plant.—In the natural course of things, plant design is a function of the engineering department, but, as in the case of the design of the product, there are many persons in the organization outside the engineering department who have suggestions to make that should be listened to. It is very seldom that workmen are asked to tell their views about new plant construction, and seldom that they are listened to if they try to make a suggestion. Nevertheless, they are the ones who make the plant profitable or not, and they know better than any one else what difficulties are placed in the way of rapid work on their part. Men are very adaptable, especially under the piece-work system, and they will learn to do work under very adverse conditions and yet do it smoothly and apparently efficiently. At the same time, they may know that a little change in the arrangement of buildings, handling devices, and so on, will make a great difference in the motions they must make and in the degree of fatigue they experience at the end of the day. Merely observing that workmen work rapidly and smoothly does not by any means show that they are efficient.

It is comparatively easy to lay out courses that work is to follow, and to make them as nearly straight lines as may be desirable; but if straight line of progress brings heavy laborious work where it must be done under the intense heat necessary to some other part of the process, or if it makes it necessary to do work requiring keen eyesight where it will have to be done always by artificial light, or if it brings delicate work where there is constant vibration from other machinery, then all the advantage of straight-line production may be annulled. No one is so likely to catch these things in a design as is the workman who is to carry out the plans so nicely made. However, workmen have their temperamental troubles as well as designers. It is not enough to let one workman from each department see the plans in advance; several should be consulted. There is likely to be considerable difference of opinion among them, and besides that, men in shops are not trained to express their opinions, but only to withhold them. Moreover, in most shops it is not customary for men to be consulted about matters apart from the detail of the work they do, and when they are asked the first time they are not likely to take it seriously, but to suspect that they are being jollied about it.

EQUIPMENT

40. Selection of Equipment.—To a considerable extent the same reasoning applies to the selection of equipment as to the design of the plant. In past days when the owner of the shop was a graduate of the same kind of shop and knew from personal contact just what could be done on every machine that was offered, he did not need to consult other people so much, while as a matter of fact he did consult them more. He was so bubbling over with enthusiasm about his business that he could not help talking it over in detail with his older and more trusted workmen. Even some of the most hard-shelled of the old school of business men were most prone to have their confidants in the shop. They may never have directly asked for advice, but they at least gave their employes a chance to express their views.

The available equipment for standardized industries is becoming more and more specialized. However, as a machine becomes more rapid in its action, and the greater its output, the longer is the time usually required for setting it up and preparing the work for it. The shop, if it has a sufficient supply of capital, has the choice of whether it will manufacture all its product in large lots to enable it to make the parts at their lowest possible cost, and store them away against the time when they will be needed, or whether it will manufacture in more nearly a hand-to-mouth manner and save the interest, insurance, and storage charges. This large decision must of course be made by the management, either intentionally, or, as too often happens, by leaving it to the shop superintendent to do as seems wise to him without any very definite knowledge of how much capital he is tying up or how much the firm has that it can allow to be tied up.

If the design of the product has been made on the basis of a long run without change of design, and the firm can depend on itself not to make every improvement that it happens to think of, then it becomes a matter of balancing interest, storage charges, and insurance on partially completed product, against saving in labor cost. Almost every job that can be done on an automatic machine has its minimum number that can be done profitably. The ideal situation is where every machine of that kind is kept permanently running on one thing, year in and year out. Such conditions are rare, however, as compared with the great quantity of work being done all over the world on a hand-to-mouth basis. Such things as the "dollar watch" which helped make the name of Ingersoll so well known, or the Ford car already referred to, justify specialization in machinery to the very last attainable degree. Other just as necessary articles, however, must of necessity follow the changing desires of the purchasers, and will require for their manufacture a much less specialized equipment. Again, and especially in woodworking and machine-shop practice, a special machine has no value that justifies it as a basis for credit at a bank, while the ordinary machine tools and standard woodworking machinery have a tangible and usually pretty well defined value and a ready sale. Thus, while the shop organization may be presumed to have the best working knowledge of the equipment needed, the treasurer needs to have a complete understanding with the shop organization as to the capital available and the dangers incurred in sinking too much of it in non-salable equipment.

41. Jigs and Fixtures.—Whether jigs and fixtures should be determined on by the engineering department or whether the latter should merely make the necessary drawings for their construction under the direction of the shop, is a question which has been debated many times and which often seems to depend on the personal qualifications of the men in charge of the two departments.

The design of jigs and fixtures, if it is decided to use them, is very distinctly an engineering problem, but one on which the advice of workmen may very well be sought. The question of how far they will be used is, like the question of equipment, one in which the capital available, the length of time a design is expected to be used, and the accuracy and interchangeability of the work, enter. The management alone can determine how much capital can be spared. It should be borne in mind that jigs and fixtures are practically a complete loss except to a going concern, and that a slight change of design may make them a complete loss even then. Moreover, they cannot well be altered to meet even slight changes in design, for they need to be preserved to take care of the repairs that are likely to be necessary to machines made when the old design was in vogue. There is a rule of practice often used to the effect that no special fixtures or jigs should be made unless they will save their cost in a year's time. Such a rule is unsafe, because in some kinds of manufacture a jig that saved its cost in five years would be perfectly justifiable, but that is only in a case where permanence of design is well established.

After it is decided to make a fixture for holding any one piece of work, say, for example, on the milling machine, the engineering department naturally makes the drawings; in some instances it may be well for the design to be accepted and the fixture made as designed, but in many other cases it is best to let every one who is likely to have the job look it over. For example, a large casting weighing 400 or 500 pounds is placed in a fixture weighing 1,000 pounds. If this is left without easy and obvious means for handling it on and off the machine or for turning it over if the piece requires it, then the fixture will be a constant source of unnecessary expense; while if it is provided with a pair of trunnions and a spreader for crane chains, it can be moved and turned over at almost no expense at all. Even in the case of the very smallest of jigs for drilling simple holes, there is likely to be opportunity for men who are constantly using them to give good suggestions. Very often in going through a shop men will be noticed using rigging of their own in addition to the jig that is intended to do the work. It may be a drilling jig and they may have to use a monkeywrench to hold it so that if the drill catches when breaking through they will not hurt their hands. This is a matter to be considered not only by the designer of the jig but also by the safety engineering department.

HANDLING MATERIALS

42. Machinery for Handling Materials.—In a watch factory, the problem of handling material in process about the shop is very small. If locomotives are to be manufactured, the problem becomes more expensive, but the solution is simple and is practically the same in all shops. Between these two extremes, there is a great range of shops where the handling problems have by no means been solved and where many more laborers are used than should be. At the very entrance to most shops it is common to find the unloading of coal and other supplies bungled, merely because at one time the wages of laborers were so low that it did not seem worth while to furnish a substitute for them. The actual handling of materials in process is, of course, strictly a shop job and must be done as rapidly as production progresses, with whatever facilities are afforded by the company, no matter how inefficiently it is done. The total cost of handling may be very small or very large, according to the nature of the business. If it is a large problem, it is usually well handled, but the shop in which it is a minor item is likely to waste much of the money which it does spend for this purpose.

When these cases are analyzed, it is often found that the trouble is that the firm feels that proper handling devices will cost more than they will earn. This may be entirely true in some cases; but there is such a supply of expensive handling machines on the market that it is not always easy to remember that there are simple, inexpensive, and adequate means for expediting much of the work. Oftentimes a roller gravity conveyer that can be moved from place to place will save its cost in a few days. Where machines are arranged in rows and parts have to go from machine to machine for succeeding operations, these gravity conveyers do the work, and at the same time make it easier for the operator than it is for him to pick up the part from the floor or a truck and then set it down again after the operation has been performed. Inexpensive overhead trolleys save a great deal of floor space that would be required to keep open paths for trucks. Belt conveyers will carry the things up which have previously been sent down the gravity conveyers. The ordinary and much abused wooden rollers for moving machinery in emergencies can easily be made much more efficient if the men who use them would only learn the principles on which they operate. It is painful to see a gang of half a dozen men tugging away to get a machine around a corner when the machine would have rolled around with only two men to push it if the rollers had been "cut" properly. All of these things are very inexpensive compared with overhead cranes, Brownhoists, and such things. They do not take the place of the latter, but they do many things that need to be done, just as quickly and well as much more expensive installations.

The planning department is perhaps in the best position to discover these little ways in which production can be expedited, and on it will fall the burden if things do not move easily from machine to machine.

43. Even when the most expensive or the most efficient handling machinery is provided, there is always some work around the shop or yard which requires manual labor. Coal, if it comes in gondolas, must be shoveled over the side unless there is a hoist with a grab bucket to take out the most of it. Even then there is some hand work necessary. Very few shops are so situated that they can dig their foundation places by other than hand power. Some are fortunate enough to have an open gravel or other easily dug land and can do it all with steam shovel, but there are always emergency jobs not large enough for the use of a steam shovel, and which must be done by sheer strength. Therefore, there will always be need of a yard gang in every plant of even very moderate size. Such a yard gang is a necessary evil, but, if handled on the basis that that is all that it can be, it is likely to be a source of more trouble than any other part of the plant. Its personnel is likely to be made up of the most ungovernable men, and the very fact that they are distributed about the plant in small groups makes it easy for them to become discontented if one trouble breeder gets in a gang. The problem is a serious one, and since the whole yard force may in some cases not exceed 2 per cent. of the total working force, it is well worth while to pay enough more for their labor so that a better class of people will be drawn into it. During the World War, it appeared as though the time was just approaching when it would be necessary to pay more for having disagreeable manual labor done than for skilled but attractive jobs. With the falling off of business, the conditions were partly reversed and manual labor has felt it more than the highly skilled, but nevertheless the little extra apparent cost of raising the pay of a very small percentage of the employes is not nearly enough to overcome the gain in morale of the whole shop or the additional work that will be done by an intelligent yard force.

The yard force and all the helpers in the shop engaged in handling materials in process are usually under the shop superintendent, he being the one in the best position to keep them under supervision, but their work most vitally affects the work of the planning department. The remaining laborers who attend to the cleaning of the shop are also usually under the supervision of the superintendent, but in some cases a separate janitor force is maintained, which may, on account of the care of the sanitary arrangements, be placed under the care of the medical department. However, the latter department is seldom in a position and hardly ever cares to assume the responsibility for work so distantly related to its own work, so all that the medical department does is to make a monthly inspection of all locker rooms and toilets.

44. Yard Switching.—If the plant is on a railroad and has switch connections in the yard, there is usually a pretty definite arrangement with the railroad by which the company keeps things clear and makes such repairs as the railroad may demand or else it loses its service. The tracks in the yard belong to the company on whose land they are laid, but it has merely physical ownership of the rails and ties. The railroad is in entire control, otherwise it will not risk its engines and cars on them. When there is use of the tracks inside the yard by the owner's engines and cars, these special cars or locomotive hoists should not go outside the yard limits onto tracks which may at any time be used by the railroad company. It is very desirable at times to have a light switching engine that can be used to move cars once set in the yard. A locomotive crane can be used for this purpose when not needed for its regular work, but such use is not economical when there is any other work for the crane, as it is not only an expensive machine but is very slow.

45. Yard Trucking.—Trucking within the plant itself is very often necessary, and the horse-drawn truck for short hauls has by no means been proved inefficient. Long-distance trucking, where the traveling time exceeds the loading and unloading time, is probably cheaper by motor truck than by horses. If the yard is well paved with sheet paving and the loads are light, the low-wheel electric truck is probably best, not so much because of any cheapness in first cost or operating cost, but because of the fact that these little electric trucks can go on elevators and can take a load from a machine on one floor of a building and deliver it on another floor of another building without having to transfer the load at all, while with the horse-drawn truck it will have to be transferred twice. The relative costs of the different methods of trucking at any time and in any plant can be computed by taking into account the cost of horses, feed, and care and repair of trucks, as against cost of storage-battery charging, decreased cost of labor for loading and unloading, extra depreciation and repair of electric trucks, and the saving in space due to the narrow passageways required for electric trucks, which can make very sharp turns.

As a rule, the work of electric trucks neither overlaps that of the overhead traveling crane nor takes its place. The crane, as has already been explained, is a great saver of floor space, saving on an average at least 5 per cent. The electric truck is useful to bring things to the crane and to take them away, for which purpose demountable bodies or boxes that can be hoisted by light chains at the corners are desirable, both to make easy attachment and to make a respectable load for the crane instead of its having to make several trips for small loads.

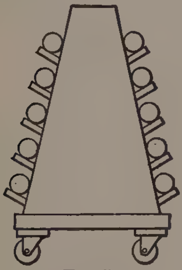


FIG. 7

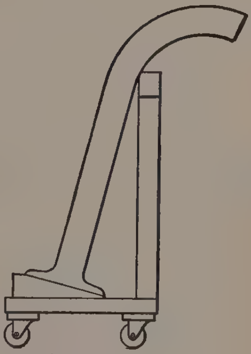


FIG. 8

Traveling cranes are a matter of necessity for certain work, and the border-line cases in which it is difficult to determine whether they are a necessity or not are few, but in those few cases the virtual addition of floor space resulting from the use of cranes is worthy of consideration.

46. Special Trucks and Stands.—Parts of machinery in process, that cannot be rolled from machine to machine, are advantageously handled by means of special trucks, such as shown in Fig. 7, which is a sectional view of a truck for handling spindles and shafts or automobile crank-shafts, or that shown in Fig. 8, which is used by a manufacturer of sensitive drilling machines. These trucks are mounted on substantial castors so that they can be readily rolled from place to place. They serve both to keep finished work from being scratched, and to keep it in shape for orderly movement about the shop.

METHODS OF ROUTING WORK

DEVELOPMENT OF ROUTING METHODS

47. Conditions Influencing Choice of Methods. Methods of manufacture can be classified as *straightaway* methods, in which the product goes in one direction all the time; and *assembly* methods, which may need the services of a planning department, as will be explained later.

Examples of straightaway methods are the manufacture of flour, of paper, wire, and so on, which require certain very definite methods that have already been standardized, but which are and have been subject to great improvement by means of automatic machinery. Thus, in the manufacture of rods from billets in the steel mill by the use of the continuous mill, the work can be made entirely automatic, even to cutting off the rod while it is still running at full speed. The processes are identical in principle with those of the earliest rolling mills, but the present-day machine does not look at all like the older types. Such manufacture becomes almost automatic in the hands of the men who have to attend to the transfers of material from one machine to another. When a man has trundled bundles of wire down a certain passageway for years, there is little need of a planning department to tell him to keep on trundling it so long as the supply lasts. The slack between machines, of which there must be some, is automatically taken up by the men, since men of the type that will work at jobs of this kind are not inclined to do more than the circumstances dictate.

The greatest amount of inventive energy has been spent, in the past, on continuous or automatic production, and the greatest engineering feats have been performed in the attempt to reduce the human element to its lowest possible terms. This is entirely natural, as it is easier to measure the work of the engineer in such products than in general manufacture. Steel-mill product is simply weighed, and the tonnage is the basis for all computations. The grade is established by the analysis of the product, and every effort is put into rapidity of production. This is so readily measured that any change in methods of manufacture can be noted in the weight of the daily product almost at once, and it is so far independent of the human element that it is a really correct basis on which to rate the engineer who puts in the new system.

48. Where, however, the human element in production is in the ascendency, the effectiveness of an engineer's plan cannot be so easily rated. For example, in a machine shop, it is always possible for a man who is well trained and who wishes to make a good record, to do anywhere from 50 to 200 per cent. more work than is customary in the average shop, using the same machinery and tools. And yet it is difficult for any one to say that men in these shops are actually loafing. They are busy visibly, but their minds are not on their work or they have not the mind to accomplish the results that they might. There is a very good example of this to be found anywhere that piece-work rates are given and the workmen do not fear a cut in them. There is seldom any flourish or evident haste in a piece-work shop. Every one starts the day at a pace he knows he can maintain; lost motion is eliminated by experience; and, while the men may not take the best method of doing the work, if left to themselves they perfect themselves in their own method so that they can readily and without undue fatigue turn out a great deal more work.

Under such circumstances, the promoter of new and more efficient machinery is dependent on the human element to prove its value to a much greater extent than if his machinery were for some one of the continuous processes. He may find, when he puts his new machine in the shop, that the piece workers have perfected their own methods so thoroughly that his own expert cannot do as much with his improved machine as they are already doing with their old machines and crude ways. On the other hand, he may provide himself with experts to demonstrate his machine and find, when it is placed in a shop where the work is all on day rates, that the men use his machine with so little energy that it proves a disappointment to the management and he is requested to take it out, regardless of the fact that his own men can make it a very profitable investment. This very fact, that the management becomes practically helpless in the hands of its employes under the old systems of management, has led to various interpositions of departments between various parts of the shops.

49. Reservoirs.—In continuous manufacture, the product of one part of the process is transferred to another process, and one of these processes may proceed more rapidly than the other. It is not always possible to take up the slack between them, even within one machine. A notable example of this is found in the progress made in rolling wire rods. The earliest process required the passage of the billet through a pair of rolls. It was then handed back by manual labor to the side of the rolls from which started and passed through again. As it grew smaller, it cooled very rapidly and had to be reheated. The next step was to make a "three-high" mill and send the rod back between the two upper rolls and then through again between the lower pair, since the central roll turned steadily in one direction and therefore the upper and the lower rolls turned in opposite directions. This was a great improvement, but it required considerable manual labor of a highly skilled nature, and the two ends of the rod were unequally cooled. The end which came through first was the last to go back, and consequently it was impossible to get the rod of equal diameter its whole length. Then some one conceived what is known as the Belgian mill, which consists of a series of three-high mills through which the rod is led so that it forms in loops on the iron floor of the shop. These loops grow larger or smaller according as the number of the passes through the various rolls is well or poorly balanced. Then American inventors evolved the continuous mill, which is simply a series of two-high rolls placed close together, and with passes that are closely designed so that there is no slack between one roll and another and so geared together positively that the increased length of the rod is taken up by equally increased speed of the rolls. In this machine, not merely does the wire rod not cool off, but it will actually increase in temperature, as a blacksmith used to illustrate by hammering a nail rod until it became red hot from his blows.

In this evolution of the rolling mill is illustrated exactly what has happened in many other cases. First, there was no effort to make rapidity of production anything but a personal matter. Then there was the introduction of a process that assured rapidity of production by the speed of the rolls that completed the product, and there was a reservoir, in the form of the loops of rod on the floor, to take care that no back tension was put on the rod in its later passes; then, last, the tuning of the machine so well that even when delivering rod at the rate of a mile a minute there would be no slack, but every part of the machine would be working at top efficiency.

So the first move in establishing efficient production is to locate reservoirs into which one process or series of processes empties its product, which in turn becomes raw material for the next step. The size of reservoir necessary is a measure of the efficiency of the shop, except in certain instances, as it exhibits to the eyes of the management material and labor tied up which should be in process and getting toward the point of salability.

Of course there are manufactured goods whose excellence is dependent on the action of time on the materials. Furniture made of green wood, varnished with quick-drying varnish and only half rubbed down, is not good furniture, leather not left in the tanning vats long enough is not good leather, but these should be looked on as material in actual process, of drying or rubbing or tanning, and not as material in a reservoir waiting for a chance to be put through another process.

50. When a shop grows to the point where one man cannot longer carry in his head everything connected with the shop, or when the old superintendent who could do it by virtue of having learned it little by little, leaves or dies, then it becomes necessary to install some form of control that will make it possible to complete machines, or whatever is made, without resorting to the emergency manufacture of several small parts which have been overlooked. Firms are always reluctant to put in anything like a planning department, because it is expensive. No group of men of sufficient ability to handle a number of reservoirs of work can be hired for what a single superintendent will do his work for. Consequently, the planning department is never installed except as a last resort, or because some one in the organization realizes that it will have to be resorted to and does not wait for the emergency actually to arise.

A reservoir in its simplest form may consist of a man and a chalk mark on the floor. This chalk mark surrounds the man and encircles a neutral zone between two departments. All the finished product of the first department is delivered to the man inside the chalked enclosure and is receipted for by him. He in turn delivers it to the next department or departments, if he is at a dividing point, but only so fast as they can absorb it. This very simple reservoir, however, is expensive, as the man in charge must for his own protection know exactly what he receives and what he delivers and to whom. He must count pieces or weigh them, as his reports show the production of the preceding department and serve as check on the succeeding department and its records. Under a single superintendent this was seldom done. Each department made its lots large enough to allow for some spoiled work, and no one knew or cared where it was spoiled, whether in the last operation, where all the work so far done was lost, or in the early stages where little but the material was lost. The superintendent did undoubtedly know pretty well where to place the blame if the allowed loss was exceeded, but he did not know where to give the credit if it was not exceeded.

It is nearly always well to combine the efforts of the planning and the inspection departments, though this practice is by no means universal; for it is important at each stage, not only to know how many parts or tons of material go through, but to sidetrack imperfect work so that more work shall not be thrown away upon it. It is human nature not to report spoiled work, but to see if it will not slip by and be credited, or to hope that the loss will be charged to some one else.

51. The gains from a reservoir system are, however, great, and much overshadow the cost, though they cannot always be measured in money. If the material in transit between departments is actually moved into the space reserved for the keeper and the inspector, it gives visual evidence of the slack in the organization, just as in the Belgian rolling mill the size of the loops of rod on the floor indicates the extent to which the different rolls fail to coordinate. If, however, the materials are kept at some other place, the records of the planning department must be depended on to show the conditions. Some superintendents are more impressed by actual castings and unfinished parts of machines, while others are impressed by figures. Inasmuch as these parts occupy the same amount of room wherever they are, it is apparently only a question of whether the floor space shall be closely covered with the machinery and the planning department have a clear floor space for its work, or whether the machinery shall be more widely spaced and the material be left beside the machine on which the last operation was performed until it is inspected and the next department is ready for it. The extra cost of dividing the transportation of the material into two steps, one from the machine on which the work was last done to the reservoir, and the second from there to the next department, can be made negligible by the use of trucks with removable bodies so that the individual parts are not taken off the truck bodies while they are in storage. In making the trucks for carrying the parts, provision should be made for ease of inspection.

52. The reservoir system is applicable to the manufacture of goods that follow a fairly definite onward march through the shop, but which may have branches from the main line for special purposes. The manufacture of grinding wheels furnishes an example. Here the work goes forward in several parallel lines according to the kind of wheel being made. The vitrified wheel, which is the most used, goes through the processes of weighing out the grain and the bond, mixing, pouring into molds, air drying, shaving roughly to shape, burning in the kiln, truing, bushing, balancing, and testing. These are the rough steps; of course there are many subdivisions possible for each. For the sake of expediting the work, dams may be thrown across the path to form reservoirs as follows:

$$\left.\begin{array}{l}\text{Weighing out}\\ \text{Mixing}\\ \text{Pouring}\\ \text{Air drying}\\ \text{Shaving}\end{array}\right\}\text{Burning}\quad\text{Truing}\left\{\begin{array}{l}\text{Bushing}\\ \text{Balancing}\\ \text{Testing}\end{array}\right.$$

Reservoirs are not possible between the operations in the first column because the movements from one operation to the other are dependent on the condition of the wheel. For example, the time which a wheel remains in the dry rooms depends on its thickness more than on any one other element, as if too wet when removed it will crush of its own weight and if too dry it will crumble during the operation. Reservoirs could be put between the operations in the last column, but do not need to be, because each shop has some definite rule of its own as to how small wheels are to be before they cease to be bushed, balanced, or tested. For example, little wheels for dental use are not bushed, balanced, or tested, while a 4-inch wheel for a cutter grinder may be bushed and tested but not balanced, and all wheels over some definite size, say 8 inches, are subjected to all three operations.

A reservoir just before the burning operation enables rush orders to secure right of way, even though they are not for the wheels which the kiln loaders would like to use to fill out their kilns. And it makes it possible to see that a proper number of stock wheels are put in, though the demand may have changed during the time which has elapsed since the wheels were first mixed.

The burning process likewise requires a considerable length of time, during which stocks may have changed so much that another revision of requirements may be desirable after burning, so that certain wheels may be rushed ahead of others which have not sold so well; therefore, a reservoir after the burning enables the rush orders, which have been burned in the smaller kilns again to be given right of way, and makes it possible to insist that they get it. As with most other products, there are desirable jobs and undesirable ones. If the work is left to the workmen, the undesirable jobs will be allowed to lie on the trucks and the "soft," or easy, wheels will be pushed along, even though they are not needed. If the choice is left to the foreman, it is likely that the good jobs will be given to the best men, the ones whom he cares most about keeping, and the more difficult wheels will be left to the men for whom he cares less. That is, the work is likely to be distributed in reverse proportion to the ability of the workmen. A continuous flow of the work which is of most consequence in the filling of orders can be insured by reservoirs properly located.

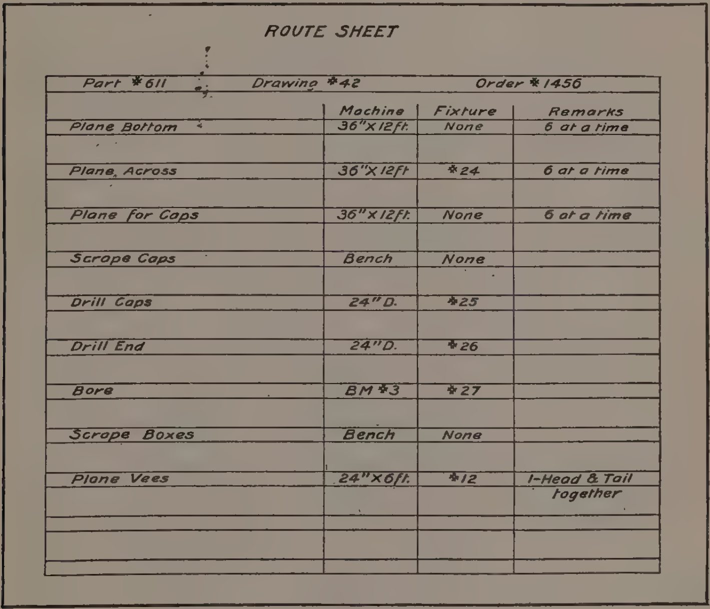
53. Development of the Reservoir System.—Whenever a branch is found in manufacture, consideration should be given to a reservoir and a means for diversion of the proper materials to the branch. For example, in the manufacture of envelopes, they may all be cut in a single cutting room, but some of them do not require printing, some do not require gumming, most of them are folded by machinery, but a few are folded by hand. Therefore, after the blanks are cut they must be distributed by some one who knows the necessities and the promises of delivery that have been made.

Even in the manufacture of wire, which is usually given as an example of continuous manufacture, there are specialties. Some wire is tinned, some is galvanized, flat wire is rolled and not drawn like round wire, there are various special cross-sections to be made, and a spring department and a wire-nail department are very natural adjuncts. All of these diversions from the regular course require reservoirs which can control the flow of product from one department to perhaps a dozen others.

54. Development of a Planning Department.—A shop with two or three reservoirs like those described can place men of intelligence and good cooperating power in charge of them without any central head and be very successful, as each of such men will respond to calls from the others and will make suitable compromises between the needs of the sales department and the most efficient working of the shop. However, the moment a time is reached when for any reason there is not perfect coordination between the men in charge of each of these stations, there is need of a central department to issue instructions which these men will carry out. If this central department, usually called the planning department, is made by calling into the central office the men who, as managers of the reservoirs, have done the individual planning, it is possible to man the actual reservoirs with men who are not allowed to take the same responsibilities and who do not wish to take them. With such conditions, naturally the salaries in the central department will be larger and those in the reservoirs much smaller.

The men in the planning department's central office have the possibility of a greater influence on the company's earnings and good standing with the customers than do those of almost any other department. Production itself can be carefully worked out, jigs and fixtures can be made which enable a uniform product to be produced, and the inspection can be most careful, but the planning department can perform its duties effectively only as men for the position can be found who accept the spirit of the department's work and who have the ability to stand out against the temptation to make temporary friends with workmen, foremen, the sales department, or the superintendent. In order that the needs of the sales department may receive proper consideration in the shop, the planning department should derive its authority from some one higher than the superintendent, possibly higher than the works manager, depending on the industry.

55. Scope of a Planning Department.—In the beginning, the scope of the planning department is determined by



ROUTE SHEET

Part #611 Drawing #42 Order #1456

	Machine	Fixture	Remarks
Plane Bottom	36"×12ft.	None	6 at a time
Plane Across	36"×12ft	#24	6 at a time
Plane for Caps	36"×12ft.	None	6 at a time
Scrape Caps	Bench	None	
Drill Caps	24" D.	#25	
Drill End	24" D.	#26	
Bore	BM #3	#27	
Scrape Boxes	Bench	None	
Plane Vees	24"×6ft.	#12	1-Head & Tail together

FIG. 9

the timidity of the management, offset by the confidence that it has in the individuals to whom it entrusts the planning. Changes from the old order of things inevitably mean friction. The friction may be all concealed; but, even if the friction is only within the minds of people who are outwardly trying to make the change for the sake of pleasing the management, just so long as any one chafes under the new conditions there is not the efficiency that is desirable. Consequently, it is desirable that the rate at which a change to a new method of organization is made should not exceed the rate at which the men in the organization can make the change in their own minds. For this reason, it is not always that a full-fledged planning department is put in at once. It may be evolved from a series of reservoirs such as have just been discussed; or it may be that a start is made at the opposite end of the line, in which case some one, possibly in the drafting room or engineering department, begins by making up routing sheets, such as are shown in Fig. 9, which become instruction sheets to the shop. When these are first presented, they may be put out as helps to the foreman; later they may be accompanied, in rush jobs, by red tags indicating the necessity for the work reaching certain stages by a certain date in order that delivery may be made when needed.

The shop routing sheets of the form shown in Fig. 9 cover the complete series of operations from the time the work is started into the shop, and the foremen are depended on to see that the work is handed from one to another. When there is friction or jealousy, individual orders may be issued to foremen to do a given operation on a piece or a lot of similar pieces. Sometimes it will happen that a clique is formed in the shop with the purpose of "getting" another foreman. A number of men conspire to make work come to him in such condition and at such times that he cannot deliver it where he should at the time it is needed, thus hoping to make the blame fall on him. Where such a condition arises, and the foremen are too valuable to let go, and probably only suffering from temporary childishness, the method of routing work from one to another is an excellent way to break up the play and to start a planning department at the same time. The forms then used are merely orders to a given department to do a given job, and to complete it at a given time, and to deliver it to another given foreman or to the inspection department or to whoever may be appropriate. While the plan is simple, it is an expense that cannot be lessened, because it requires clerical work by a mechanic, and that is always expensive; for there are so few mechanics that can do clerical work that it is usually necessary to make two jobs, a mechanic to decide how to route the work and a clerk to make the orders. Once this is done, however, it is only a matter of gradual and slow expansion to have a full-fledged planning department.

56. Functions of the Planning Department.—The functions of a complete planning department cover the direction of all work in the shop, so far as it concerns methods of doing the work, routing it, and seeing that the methods and routing are followed. The planning department does not interfere with foremanship, in regard to the directions to the workman, but it does give definite directions to the foremen as to the machines to be used and the equipment to be provided for each job. The department usually has nothing to do with rate setting, nor does it usually exercise control over the erecting floor, except in such cases as erection or assembly is standardized and becomes a known or knowable quantity. Inspection usually goes along with planning, so that the department may catch errors of method as well as errors in operation.

As a usual thing, the work of the planning department begins with the material bought by the purchasing agent and ends at the erecting floor or at the final assembly; final assembly is here mentioned, for many times a partial assembly of units is made and these are in turn assembled into the complete product. The endeavor of a planning department is always to have work planned ahead of the shop, so that there is at least one job ahead of every machine and every man, to see that the materials, tools, jigs, and fixtures, and every other thing necessary to efficient production are at the machine before the operator has completed his last job, and that the drawings and every instruction necessary are at his elbow long enough beforehand so that he can know definitely what is required of him.

Planning is primarily a function of superintendence, but since the planning department is in a position to speed up any one part of the work or to slow another down, it should, as already suggested in regard to reservoirs, be in close touch with the sales department, and be in a position to expedite work that requires it, and to see that red tags, signs of hurry, are not attached to things promiscuously without regard to the actual needs of the case relative to the rest of the jobs in the shop. The planning department should, therefore, be in a position to form a correct judgment as to the needs for hurry. Likewise it should have as long a look into the future as any one; therefore, the head of the planning department should be a man who is taken freely into the counsels of the management and who knows all their hopes and fears for the future condition of business, and he should reflect these things in the way he puts work into the shop. It is usually not a function of the planning department to say what product shall be made for stock as a whole, but the department is usually in a position to put into the shop enough of the parts that require long processes so that the firm will not be caught napping if orders begin to come in for quick delivery.

57. Routing of Work.—The first step of the planning department, that of routing the work, may be very simple and perfunctory, as in the case of a corset shop where all of the product goes through the same operations and the variations are within those operations. The other extreme, perhaps, is in the machine-tool business where there may be two or three alternative routings, which may be used according to the exigencies of the case. The routing of the headstock of an engine lathe furnishes a good example. The following routings are used, and several more variations are possible:

1	2	3
Plane bottom (flat)	Plane bottom (flat)	Plane vees
Plane across	Mill for caps	Mill for caps
Plane for caps	Mill across	Drill for caps
Scrape in caps	Scrape in caps	Drill end and bore
Drill for caps	Drill all holes (jig)	Drill bottom
Drill bottom	Bore for boxes	Scrape in boxes
Drill end	Scrape in boxes	
Bore for boxes	Plane vees	
Scrape in boxes		
Plane vees		

Diagrams showing these routings appear in Fig. 10. Of these it is evident that No. 1 has the simplest appearance.

This is the old way, still used in shops that have not the complete equipment which they would like. It does save transportation, but on the other hand the different operations require more skilled workmanship and give less certainty of interchangeability than either of the others. In No. 3 are included all the operations that need be performed, but all the drilling and boring is combined under one head and is done in one jig, but with interchangeable and quick-change drills and boring bars. One transfer to the scraping bench is avoided by making the milling work so close that it is not necessary to scrape in the caps; this is entirely possible though not always attempted.

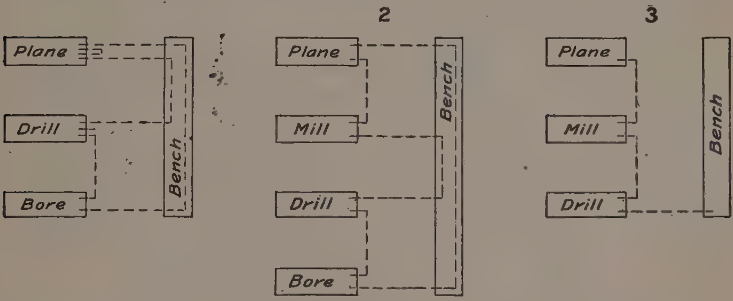


FIG. 10

From this example, it is easy to see that routing work is not merely a question of using the most direct route geographically, but that it is always a compromise between the best methods of doing individual jobs and the best methods of attaining complete production. In such instances as have just been discussed, it is possible that it may be wise planning to change the routing of the work during its progress. For example, it may be that gang mills exist for milling the cap seats, but that they fit only one milling machine and that machine is tied up with a long and important job; then it may be much better to revert to the planer with its skilled workman than to let the work lag while waiting for the milling machine to complete its long job.

As a usual thing, planning departments are expected to do the best that can be done with the equipment and tools that have been provided, but it is certainly part of their job to present new ideas to the management as to the best arrangement of machinery and the best machinery to have. They are in the very best of positions to have a comprehensive view of the whole matter, as they see the job as a whole, while an individual foreman sees only the flow of work through his own department and cannot be expected to give as much credit to the things which others say about the flow of work as he does to what he sees himself.

However, the planning department is also in a position to see the great cost of perpetual shifting of machines from one place to another, and is in a better position than any one else to realize the care which should be taken before being too much carried away with the craze for special machinery. Moreover, it should also be careful about the desire to cut down distance of travel between operations. Distance counts for little. It is the unloading or unfastening from one machine and the setting up and fastening on another machine that counts. A simple fixture on a planer or a milling machine so that castings can be made ready for machining in seconds instead of minutes will offset a great amount of distance travel. A sufficient supply of these fixtures or *cradles* so that they can accompany the castings from the planer to the drill will often make the drilling job so quick and simple that the castings might be carried a mile to another machine without costing as much as has been saved.

58. Routing Work to Specific Machines.—So long as work is routed in a general way and the instructions come to the foreman to plane this place before that one is drilled, or the reverse, there is little friction with or among foremen, though even then one will occasionally be found who disregards instructions so long as he can keep the work in his own department. When it is decided to have the planning department route the work to specific machines or benches then there is a very considerable chance that friction will be created. This may be handled in one of two ways. The most common is by means of a definite written or oral order to the foremen. This stirs up all the antagonism at once and it all simmers down together, except in a few individuals who under this plan are demoted or dispensed with altogether. If the plan is strictly adhered to, there is not usually much trouble; but if the superintendent has a few favorites among the foremen whom he "tips off" that they make take liberties with the planning-department routing, or if he tells the men to come to him with any complaints as to the routings which the planning department may make, then there is little chance of any but confusion and probably ultimate dissolution of the department.

The other plan is to place the whole problem before the foremen in a written communication and then to assemble them and ask them to criticise it, not from their own personal standpoint but from the standpoint of the good of the company as a whole. If the matter is put to them as a thing that is made necessary by the growth of the company and not because of any lack of ability on their own part, and if they are represented by one of their own number in the planning department, then there is a very good chance of success, because the men who do not fall in line will not have the support of the majority of the other foremen.

It is perfectly true in almost every case that the installation of a planning department is not a criticism of the foremen. It means that the problem has grown so large that the men whose noses are held to the grindstone by force of circumstances cannot expect to have a large, broad view of the problem as a whole. Moreover, it has been the experience of all time that the good of the whole demands some sacrifice of the best of each part. Even in nature the vegetables which have the best leaves and the strongest stalks do not always have the best fruit. Corn raised for ensilage has no ears worth mentioning, and corn raised for the ears is not nearly so rank in growth. In just the same way the details of a business must be subordinated to the best interests of the whole. When this is insisted on, however, as when a planning department begins to route work to individual machines, then there should be some way by which each foreman and, if possible, each workman should know what the interests of the company are and be in some way enthused with the spirit of the company and rewarded not only for personal efficiency but for cooperation and self-sacrifice. It should be fully recognized that it is a sacrifice for a foreman to allow others to come into his department and virtually "tell him how to run it," especially after the many years during which foremen have been building up reputations for themselves. However, if the management will show its appreciation for cooperation in the way that shows it most certainly and definitely, that is, through the pay envelope, then cooperation becomes a thing to be given, and it is only the most stubborn foreman that will forego an increase in salary for the sake of maintaining his own way.

59. Visual Routing.—It is easy to say that the planning department shall route work to machines, but routing is a very confusing job without some kind of mechanical assistance. The simplest possible plan is to have a large board with a peg for every machine and branch station to which the planning department may wish to route work. On the pegs can be hung tags giving the name or shop designation of the job to be done. Each tag stays on the peg until the job is reported complete. Consequently, there should always be at least two tags on every peg, one for the job being done and one for the next job to be done. Experience shows that some machines will have work assigned to them far ahead in point of time, and the pegs for other machines will be deep with tags for very short jobs. For example, the largest planer or lathe in the shop is usually in great demand and has to have its work planned far ahead in order that machines may have their largest part completed in time to begin assembly; but a key-seating machine may complete a dozen or more jobs in a single day.

In the case of the planer mentioned, the order in which the jobs are done is of considerable moment, but the jobs run long enough so that ample time is given for serious consideratior of the time when other parts will be ready for assembly. The key seater on the other hand usually has a great many short jobs and only a few long ones. The order in which the work comes to it is therefore not nearly so important, except that care must be taken to make sure that a long job does not have to be broken up to do some very short one. This is easily managed with the tag system, for a man can run through all the tags that have accumulated ahead of the key seater and pick out any jobs that must be completed at an earlier date than the time consumed by the long job will allow, and get them out of the way before the long job is begun. The tag system is simple and easily started, and makes it possible at a glance to see that every machine is provided with work. It also enables a subordinate department of the planning organization to get the tools and material to the machines before the work then being done is completed, and thus saves time spent by workmen getting these things, which necessarily would mean lost time for the machine.

60. The tag system does not fill all the requirements, because it does not show how the different parts of a given machine or lot of machines are progressing. Theoretically, each part of the machine should start into the shop at just such a time that it will be complete and ready for assembly at the same time that the principal member of the machine is ready to receive it. For example, in the manufacture of automobile engines, if it requires three times as long to machine the cylinder castings as it does the pistons, the pistons should not enter the shop until the cylinder castings are two-thirds done. Of course, it is not safe to plan in this way without any margin for errors and unforseen delays, but within reasonable limits it is feasible. For the purpose of controlling this flow of parts, another board, called a control board, may be installed for each group of machines. This board would be arranged in some such way as is indicated in Fig. 11, in which horizontal lines represent parts of the machines being built, and vertical lines represent working days, dating *backwards* from the time when assembly should start. On each horizontal line a starting point, or time, for work on that particular part is indicated by the letter *a*. This point is located a sufficient number of days before the time for assembly to allow ample time for completion of the part, with allowance for delays. Back of this point is another marked *b*, which indicates the time when steps must be taken to supply the material needed, and *c* indicates the time for securing the tools and fixtures necessary.

When the time indicated at *b* is reached, inquiry is made of the stores department to see that the material needed is in stock or that steps are taken to procure it through the purchasing department. Then, when the time *c* for getting out the tools is reached, they are requisitioned from the tool rooms and charged to the machine at which they are to be used. Then as the time *a* for starting the work is neared, the proper tags are made out and hung on the appropriate pegs on the routing board, which was previously described.

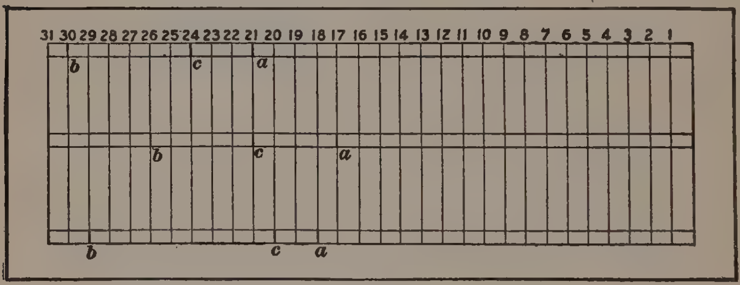


FIG. 11

61. Of course there are many minor modifications of these plans. Some shops, for their control boards, use slanting shelves on which they place blocks bearing symbols of the parts, as shown in Fig. 12. Others use the shop orders themselves, instead of tags, on the routing board; but that is not good practice unless duplicates of the orders are made, as it is desirable for each tag or its equivalent to stay on the board until the job for which it calls is complete. The exact method to be followed is dependent on the product being made. A machine-tool shop might have forms very different from those required by a manufacturer of ladies' slippers; but neither can be worked out without a thorough acquaintance with the work being done. Every one should be on his guard against blind copying of methods or forms, because in the same general line of manufacture, even in the same identical line, there is a great chance for different methods to be successful. For example, suppose that the work is the manufacture of wringers. All wringers look very much alike to a man who has only noticed that they are a necessary part of his home laundry equipment, but the methods of manufacture may be entirely different in different shops and yet each shop may turn out a perfectly acceptable machine. The routing in one shop may necessarily be quite different from another, owing to minor differences in design and to differences in equipment. The forms on which the different directions are given may need to be far different. For example, a small machine part requiring only a few minutes' total time for machining may have several operations performed that require a drawing on which are specified not only the dimensions of the piece, but

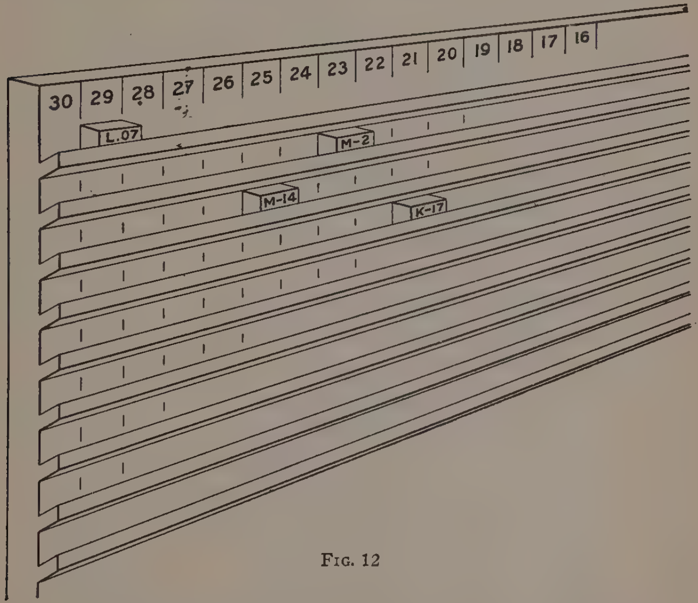


Fig. 12

the limits within which the dimensions shall be correct, the material of which the part is to be made, and specific instruction that operations shall be performed in a given order because of the necessity of making some of the later measurements from a base plane not ordinarily used. All these instructions from the engineering department must be followed even though the planning department feels that it could do the work more efficiently if allowed greater latitude.

62. Control of Tools and Fixtures.—Under the old system, a set of tool-room checks was given to each employe, and these checks were exchanged by him for the tools for which he saw fit to ask. No limitations were made, and he went at his work as he saw fit, unless stopped by his foreman. Under the planning system, the individual workman should have very little reason for visiting the toolroom, but the tools and everything else needed should be brought to him at his place without any action on his part. It is true that there are many places where each man is still allowed to pick out the tools he wishes, but the number is growing less all the time. If the planning department knows enough to plan the work, it should certainly know what tools should be required. To the extent of honoring requests for tools at the proper time, the tool rooms should cooperate with the planning department. In fact, since almost all their dealings are with the planning department it is natural to count the tool rooms almost as a part of that department. However, the planning department has enough to do without adding to it the actual design of small tools and fixtures, which is strictly a mechanical matter, after it is once decided to supply them. So it is desirable to place all designing, whether of the product or the tools and apparatus for making it, in the hands of the engineering department, which presumably is in a position to do that best. However, it is necessary to check a true designer, as otherwise he will bankrupt any firm with his new ideas which he wants to see expressed in expensive metal before they are digested and before the public has been educated to want them.

The planning department, then, should function as the ordering agent of the company, so far as tool rooms and stores of materials are concerned. It should, therefore, be assured that its orders will be honored promptly so that there will be no danger of loss of production from failures to supply tools and materials as ordered.

Very few superintendents realize how much is lost through lack of prompt supply of tools and material. They do not realize, or they forget, how skilful men become at "stalling" on the job. No workman cares to call down disapprobation by appearing to be loafing, even though it may not be his fault. Therefore, as he sees the end of one job coming and the next job not in sight, he slows down, spends more time fiddling over his tools, finds a place where the machine needs readjustment, and otherwise busies himself doing nothing that advances production. If any one questions this statement, let him give his own private secretary only half the usual work for a few days and watch her spin it out so that she will always appear to be busy. The same thing is occurring in the shop every time there is a delay of materials, every time that a man has to wait for another man to get through with a machine or a tool. When, as often happens, an erecting gang has to wait for a special wrench, the whole gang does not sit down and frankly wait. They busy themselves doing nothing, or, worse than that, they take off some part that is already well fitted and pretend to be adjusting it again. To be sure, if they are on piece work they may put up a fight for more tools, but even then the habit of years of hour work has so strong a hold that they find it impossible to appear to be loafing.

The planning department, therefore, should be in a position to demand, and get, an adequate supply of small tools and fixtures so that the most efficient production is reached consistent with the size of lots that can be put through.

63. Size of Lots.—Manufacture ranges from entirely continuous manufacture, in which a continuous flow of material is always passing through each operation, to the manufacture of specialties, where a single machine may be under construction with no prospects that another will ever be made. Between these two extremes there is a great range of choice in regard to the size of lots put through the shop. The size of these lots is influenced by the knowledge that the sales department has of the market, the condition of the company's treasury, the state of the money market and the company's credit, and the nature of the shop's equipment. The planning department is the department which must carry the brunt of the load whenever it is decided to increase the size of the lots carried through. It knows, first of all, whether the equipment will stand the increase, whether each lot will take twice as long to go through the shop if the size of the lot is doubled or whether the setting-up time is so great in proportion to the time that is spent on the operations that the handling in larger lots will actually speed up production by the year even though it slows down the delivery of each lot.

64. Effect of a Planning Department on Foremen. Under the plan proposed by Taylor, foremen in the old sense were to be replaced by men each of whom exercised certain functions in which he was an expert. These men were as follows: A teacher of quality of work, really an inspector on the job; a teacher of methods, motions, and procedure; a man to see that the most efficient speed was maintained; a repair boss who took over the workman's machine for the time being for any necessary repairs, whether to the machine itself or its driving mechanism; a time clerk, who exercised full authority over the workman so far as his relations to the pay roll and the reporting of work accomplished were concerned; the routing boss, whose business was to see that the work came to the workman in its proper order; and on top of all these was a disciplinarian.

While all this looks at first sight like flying in the face of Providence, and calls forth quotations about serving one master, the fact is that each of these functions is so fully defined in shops which Taylor reorganized that each man knows well to what foreman he is responsible for certain things, and each foreman, knowing so well his own limits, is not tempted to go over into another man's field. However, not many shops have taken over the Taylor system unmodified.

The function of such systems which has made the greatest impression is that which the planning department offers, and even that function is very often used without any difference in the foremanship, except that the foreman finds that his choice of jobs for given machines and men is overruled. Theoretically this is right, but practically there is found to be a great difference in the ability of men who are of necessity entrusted with similar machines. If there is but one big lathe, then all the work over a given size must go to it, no matter what the method of routing is, but if there are a hundred 18-inch lathes, then there must be a hundred different qualities of men handling them. The man at the planning board cannot visualize these men and their qualities, and yet that is just what the foreman has to deal with. He may find that one man is really very good at thread cutting, but makes a fizzle of every face-plate job that is given him; and yet the planning department may very likely send a job of face-plate work to that very lathe, and the foreman has to spend a great amount of his own time getting the job done. However, a little tact on the part of the foreman will give the planning department this information and secure its cooperation, which may consist of some private mark on the planning board which signifies that all face-plate work should be kept away from that particular machine. It is only good cooperation for the foreman to let the planning department know these peculiarities of his men and equally good cooperation for the planning department to heed the advice.

65. Of course, every shop is likely to have foremen who know so much more about how the work should be done and how it should be routed through the shop, that they try to find flaws in everything that the department does. Naturally, they can find flaws, because it is so much easier to tear down than to build up. But if the shop is to be run for its best profit, the organization must be cooperative. Men who do not and will not cooperate, in spirit as well as in material things, simply have to make way sooner or later for those who will. However, it should be borne in mind that a foreman who makes a constructive suggestion is entitled to be heard, and to know just what the objection is to adopting it, if there is any. If he is not told then, he is likely to think that there may have been an ulterior motive. Once he begins to be suspicious, there is no knowing just what he may do, for suspicion breeds suspicion; therefore, as a part of his education, the firm will find it advantageous to tell him just what the reason is. Not many foremen realize that the firm has any limitations in the expenditure of money, and not many realize the sales problem nor the dangers of overproduction, and unless these various sides of the question are explained to them they will judge the firm from their somewhat narrow viewpoint.

Foremen like to have a large amount of work from which to select the jobs for each man to do when the one he is on is completed. Such a condition is desirable from the standpoint of suiting the ability of each workman, which is something that is quite likely to be inefficiently done with a planning department; for there is seldom a great gain without some small loss. The gain in available room in the shop due to the smaller amount of work in process, and the gain in capital account from having less material in all stages of manufacture all over the shop, is enough to compensate greatly for this one possible loss. Many a firm has been driven into a receivership by the stock in process, which if turned into cash would have saved them. The only way to avoid having so much in the shop is not to start the material moving until the shop is in a position to use it. This does not of course apply to manufactures in which the material is required to season, as in the furniture business, but it applies even there so far as the room in the shop itself is concerned. Foremen, therefore, should be made to see the advantage to the shop as a whole which comes from having only live work going through and from the keeping of all the stationary material in store rooms if it is necessary to have it at all.

66. The Planning Department at the Erecting Floor.—It is plainly the job of the planning department to see that all the parts and tools necessary for assembly of the finished product arrive at the erecting floor when they are needed. The question arises, should the department attempt to plan the erection? This depends on the product and on whether the product is assembled piecemeal or all at once. If the product is a machine tool, like a lathe or a planer, the assembly is around a main casting, or bed, of the machine and all the parts are fastened to or fitted to it directly or indirectly. In most cases, the final assembly consists in attaching parts that consist of other parts already assembled elsewhere. In cases of this kind there is no doubt that the planning department should direct the time of assembly of the units which go to make up the completed whole, so that they will arrive at the final assembly at the proper time.

In other cases the assembly floor is too small for random erection work and the time of assembly may be fairly definite and regular. This applies to work that is manufacturing, in distinction from merely building a machine. An engine-building shop may make a series of small standard, stock engines, which are assembled in certain established ways and for which the assembly time is fairly constant because the parts are made with fixed tolerances. At the same time, they may build some large engines, that are made singly and the erection of which is not a known quantity and which it would appear to be foolish to ask the planning department to supervise, because it can only guess at the obstacles that will be encountered. There probably are instances in which the original drawings have been so well and carefully worked out that the machine goes through without alteration and all the clearances are found to be ample; but that is the exception that proves the rule and is very likely more due to luck than to skill. Generally, every new design is found to have some things that have been overlooked and some things that have to be changed, and that cannot be predicted by the builder. In such cases the planning department cannot fairly be asked to assume responsibility for the progress of the machine, but it can be held responsible for the arrival at the erecting floor of parts which should fit into their proper places if the design is right.

In some cases, there are parts that cannot be completed until assembly has been begun. For example, there are certain bearings on many machines that have to be correctly alined, and the alinement cannot be made with certainty except on the machine, the parts being afterwards removed to make the fitting permanent. Such work is hardly ever within the work of the planning department, because it is an uncertain matter which is necessary to the perfection of the machine and which must be done well no matter how long it may take. It is, however, often possible to assign certain machine tools to the use of the erectors only, even though these machines may stand idle for a time, as the advantage of keeping the work of erection going continuously is of great importance.

MEMORY HELPS

He who can answer the following questions from memory has a good understanding of the text in the preceding pages.

(1) What possible dangers are connected with the attempt of a firm to control its original sources of raw material?

(2) By what means may a purchasing agent arrange his buying so as to be able to take advantage of bargains that may be offered him?

(3) What is a line organization?

(4) When is the making of a flow sheet desirable?

(5) What are the advantages and disadvantages of the use of committees to decide questions on which those in authority in an organization disagree?

(6) Why should the sales department have a voice in regard to the design of the product manufactured?

(7) In a manufacturing business, when is the need of a planning department indicated?

(8) What are the functions of a planning department?

(9) By what means may the planning department always know that a suitable amount of work is assigned to the various machines?

(10) What are the considerations that influence the size of the lots of the various products manufactured in a shop?

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